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ORIGINAL ARTICLES.

I.—Eminent Living Geologists. No. 8.

Professor Joseph Prestwich, D.C.L., F.R.S., F.G.S., F.C.S., Assoc. Inst. C.E., Corr. Inst. France, etc., etc.

(With a Portrait.)

OUR venerable friend Professor Prestwich, who has now attained his 82nd year, may serve as an admirable illustration of the law of "the survival of the fittest," for years have failed to dim either the brightness of his eyes, or the clearness of his intellect; the only sign of advanced longevity being the inability to undertake those long walks over the Chalk Hills around Shoreham, in which he, till lately, delighted to indulge.

Mr. Prestwich is one of the few survivors of the second generation of great British Geologists, who were led by Buckland, Sedgwick, Conybeare, Fitton, De la Beche, Murchison, Scrope, and Lyell; and who had for his contemporaries Agassiz, Phillips, Owen, Darwin, Godwin-Austen, Forbes, Morris, Ramsay, W. Smyth, S. V. Wood, Wetherell and Edwards, all of whom have, alas, passed away, whilst his older surviving geological friends Sir John Evans, Rev. O. Fisher, T. Rupert Jones, R. Etheridge, and others, are all his juniors. During his long life Professor Prestwich has witnessed great changes of views and vast increase of knowledge in his favorite science of geology. In his boyhood, when Buckland began to lecture at Oxford, on the "new and curious sciences of Geology and Mineralogy," geologists had only begun to suspect the importance of cave-remains, and of the discovery of bones of recently-extinct mammalia. Although his earliest triumph was won by his memoir on "The Geology of Coalbrookdale," and his later studies led him to become the first authority on the water-bearing-strata around London, yet he was destined to be the investigator who first demonstrated to English men of science that the flint implements, found in the valley of the Somme, in contiguity with fossil mammalia, were genuine works of man, contemporaneous with extinct animals, a conclusion which might readily have been reached long before, but for the absolute prepossession in favor of the views of man's limited existence upon the earth which were then current.

The descendant of an old Lancashire family, Joseph Prestwich was born at Pensbury, Clapham, near London, March 12th, 1812.

He received his early education near London, passed two years at Paris in a school attached to the College Bourbon, thence he was

transferred to Dr. Valpy's at Reading, and finally entered University College, Gower Street, then just established.

He was a diligent student under Dr. Turner and Dr. Lardner in the Chemical and Natural Philosophy Classes, somewhat to the neglect of his classical studies.

At that time a student of geology had to be his own master and teacher. There was hardly a text-book and no public lectures, except three lectures on mineralogy and geology forming a part of the course of forty lectures by Dr. Turner on chemistry. The proximity of the British Museum he found of great advantage for the study of the geological and mineralogical collections between lectures.

Whilst still a student at University College, he started a Society amongst young men of his own age (from 18 to 20), each of whom engaged in turn to deliver a lecture on Chemistry or some branch of Natural Philosophy. There were about fourteen members who met regularly in rooms in Surrey Street, Strand, where they had a small Laboratory, and styled themselves the "Zetetical Society." But by degrees, owing to professional and business engagements, the Society was broken up.

Mr. Prestwich's own tastes would have led him to adopt a profession, but circumstances caused him to enter into business in which he remained closely engaged until the year 1872. He was frequently in France and Belgium between 1836 and 1850, which gave him the opportunity of making the acquaintance of most of the French geologists, including Deshayes, Hébert, Chas. D'Orbigny, Lartet, D'Archiac, Desnoyers, Constant Prevost, Delesse, De Verneuil, Omalius d'Halloy, Dumont, de Koninck, and later on with Gaudry, Daubree, Belgrand, Gosselet, Nyst, Dupont, and others; many lasting friendships were thus established.

Mr. Prestwich's first paper was on the "Gamrie Ichthyolites," to which the then scarcely known Hugh Miller, of Cromarty, had just directed attention. His holidays in 1831-32 were spent in the investigation of the coal field of Coalbrook Dale, and his memoir thereon, with the description by his friend Professor Morris of various new species of plants and mollusca, showing the horizons to which each of them belonged, was published four years later in the Transactions of the Geological Society of London.

This paper was followed by a series of others, printed in the Quarterly Journal of the same Society, on the structure and organic remains of the several groups of strata of the London and Hampshire Tertiary Basins. In these memoirs he established the existence, at the base of the known deposits, of a marine formation which he designated the "Thanet Sands," proved the synchronism of the barren mottled and plastic clays of Reading with the fluvio-marine beds and fossiliferous pebbly sands of Woolwich; and showed that the London clay was not the equivalent of the Bracklesham and Barton beds, but that it occupied a lower zone, and was synchronous with the Bognor beds of the Hampshire Basin.

This re-arrangement of the English Eocene series necessitated a revision of their correlation with the same strata in France and

Belgium. Mr. Prestwich showed, on the evidence of their organic remains, that the Thanet Sands were the equivalent of the lower *Système Landenien* of Dumont, whilst the Woolwich and Reading beds corresponded with the upper *Landenien*; the London Clay with the *Système Ypresien*; the Bracklesham Sands with the *Système Bruxellien*; and the Barton with the *Lackénien*. In the Paris basin, Mr. Prestwich could not recognise the Thanet Sands, but considered that the marine sands of Bracheux, which also repose on the Chalk, were the equivalent of the lower estuarine sands of Woolwich, and of the more entirely marine green sands of Richborough; and he further showed that the sands under the *Physa* beds at Rilly should be referred to the same zone, whilst the *Physa* bed itself he considered to be a local deposit intercalated in the lower part of the same Woolwich series—a conclusion contested, at first, by the French geologists. The London Clay he placed approximately on the level of the *Sables Coquilliers* of D'Archiac, whilst the *Calcaire Grossier*, before referred to the London Clay, was identified by him with the middle Bracklesham and Bagshot Sands; and the Barton beds with the *Sables des Beauchamp*.

In the meantime, Mr. Prestwich's attention had been directed to the more recent superficial or Quaternary deposits, and it was while engaged on these that the discoveries of M. Boucher de Perthes relating to the palæolithic flint implements attracted his notice. These discoveries had been known to geologists, as were those relating to analogous discoveries elsewhere in caves, for many years; but they failed to satisfy geologists, and were received with incredulity both in England and France.

Mr. Prestwich had been intending for some years to examine the evidence personally, but it was not until 1859, at the instigation of his friend, the late Dr. Hugh Falconer, who had long held the same views with respect to the probable antiquity of man, that he was able to undertake the investigation of the drift deposits of the Valley of the Somme. By this inquiry to which he invited the coöperation of Sir John Evans, Godwin-Austen, and other geologists, he quite satisfied himself and them that the flint implements were the work of man, and that they were lying in undisturbed beds of sand and gravel, in conjunction with the remains of extinct mammalia, as had been asserted by Boucher de Perthes and Dr. Rigollot; and his paper before the Royal Society at once gained acceptance for his views amongst geologists.

Mr. Prestwich, in a subsequent paper, showed that the flint implements occurred on two or more levels, which he designated as the "high- and low-level valley gravels," and that the former were formed and deposited before the excavation of the valley in which they occurred, and therefore vastly extending the antiquity of these deposits. The loess with which these gravels were associated was shown not to be the result of one flood or of lakes, but to belong to different stages of the formation of the valley; to be, in fact, a silt deposited during floods of the old rivers at several periods of their existence.

As a cognate subject bearing on the Antiquity of Man, Mr. Prestwich drew up in conjunction with Mr. Busk, at the request of the Committee of Investigation, the Report on Brixham Cave, published in the "Philosophical Transactions" in 1872. Subsequently he brought out the first of his papers on the Pliocene and Pleistocene series, commencing with the Crags of Norfolk and Suffolk, between which and the Crags of Belgium he instituted a comparative examination of their organic remains; while in another paper, also read before the Geological Society, he has shown at how recent a date some of the important disturbances affecting Portland, and the valley denudation of the South of England have taken place.

These were followed by a paper read before the Institute of Civil Engineers, "On the Geological Conditions affecting the Construction of a Tunnel between England and France," in which he discussed the lithological characters, range and dimensions of the several formations on the two coasts, and showed that the Palæozoic strata offered the safest passage, but that their depth was a very formidable bar. He afterwards brought before the same institution a paper "On the Origin of the Chesil Bank," in which, differing from previous observers who attributed it to shingle, drifted from the Dorset and Devonshire Coasts, he showed that it was due to the wreck of the old "Raised Beach" of Pleistocene age, that he had before described and of which a remnant still exists, twenty-five feet above the sea-level, on the Bill of Portland, and which formerly stretched thence to the Devonshire and Cornish Coasts on one side and to Brighton on the other.

In 1874, in another paper to the Royal Society, he brought together and reduced to a common standard all the observations on Deep-sea Temperatures made between the years 1749 and 1868, from which he deduces certain facts with respect to the flow of deep-seated currents, the position of the bathymetrical isotherms, and their bearing on some geological phenomena.

When the Royal Coal Commission was appointed in 1866 Mr. Prestwich was one of its most prominent members, and in that capacity he drew up two of the sub-reports—the one "On the quantity of Unwrought Coal in the Coal-fields of Somerset, and the other, "On the Probability of finding Coal under the Newer Formations of the South of England," of which he took a favourable view. He was also one of the members of the "Royal Commission on Metropolitan Water Supply of 1869."

At a meeting of the British Association, at Swansea, in 1880, he brought before the Geological section some observations which tended to show that the South of England, and probably great part of Western Europe, had been submerged at a very late geological time, and that this event marked the line between the great Mammalia of the Quaternary period with Palæolithic man, and man of the Neolithic or recent period. These views, however, met with considerable opposition. At the York meeting in 1881, he gave an outline of his researches on the strata immediately underlying the glacial series; and in another paper he contested the generally

accepted theory of volcanic action, that it is due to the agency of high-pressure steam in the Volcanic foci, and contended on the contrary that water was a secondary and not a primary cause in this action, and its action he showed to be the necessary consequence of the hydro-geological structure of volcanic mountains.

Mr. Prestwich was appointed by the Vice-Chancellor of the University, Dean Liddell, to succeed Professor Phillips in the chair of geology at Oxford in 1874.

On theoretical points Prof. Prestwich holds anti-uniformitarian views, some of his reasons against uniform action in all time being given by him in his Inaugural Address at Oxford in 1874, and in his "Geology." He also opposes Croll's time theory.

Professor Prestwich has published three lectures on the Geology of the neighbourhood of London, entitled "The ground beneath us," and a work on the "Water-bearing Strata around London," with a view to fresh sources of supply for the Metropolis; also a pamphlet on the Water supply of towns, more especially of Oxford.

In 1876, in investigating the conditions for a better water supply, he pointed out that there was under Oxford an abundant source of mineral water, allied to but stronger than those of Cheltenham and Leamington. The *vexata questio* of the "Parallel Roads of Glen Roy" next engaged his attention, and this was followed by several other papers, amongst which may be mentioned those on "Underground Temperatures" and on "Volcanic Action."

As far back as 1849 the Geological Society awarded Mr. Prestwich the Wollaston Medal for his researches on the Coalfield of Coalbrook dale, and those on the Tertiary districts of London and Hampshire. In 1865 the Royal Society awarded him a Royal Medal for his contributions to Geological Science, and more especially for his paper in the Philosophical Transactions, "On the Occurrence of Flint Implements associated with the Remains of Extinct Species of Mammalia in beds of a late Geological Period in France and England;" and that "On the Theoretical Considerations on the Conditions under which the Drift Deposits containing the remains of Extinct Mammalia and Flint Implements were accumulated, and on their Geological Age."

Professor Prestwich served the office of President of the Geological Society of London from 1870–72. He was made a Vice-President of the Royal Society, 1870–71. In 1874 the Institute of Civil Engineers awarded him a Telford Medal and premium for his paper on the "Geological conditions affecting the construction of a Tunnel between France and England."

At the annual *Réunion* of the Geological Society of France, at Boulogne, in 1880, Professor Prestwich was elected President of the meeting; and in 1885 the Institute of France elected him a Corresponding Member of the Academy of Sciences. In 1886 the first vol. (Chemical and Physical) of his work on "Geology" was published by the Clarendon Press. The second vol. (Stratigraphical and Palæontological) with a Geological Map of Europe appeared in 1888. In the same year the University of Oxford conferred upon

him the honorary degree of D.C.L. He was elected President of the "Congrès Géologique International," which held its session in London in September, 1888. His latest papers were read before the Geological Society of London, "On the pre-Glacial Drifts of the South of England, with a view to determine a base for the Quaternary Series, and to ascertain the Period of the Genesis of the Thames Valley" (see Quart. Journ. Geol. Soc. 1890, vol. xlvi. pp. 84, 120, 155). "On the Age of the Valley of the Darent and remarks on the Palæolithic Flint Implements of the District," etc., in which he shows that on the high chalk plateaux of Kent there are flint implements of a peculiar rude type fashioned by a race of men of much greater antiquity than those who made the implements of the Thames and Somme Valleys (*op. cit* vol. xlvii. 1891, pp. 126–163). "On the Raised Beaches and 'Head' or Rubble-drifts of the South of England," etc. (*op. cit.* vol. xlviii. 1892. pp. 263–343). "On the Evidences of a Submergence of Western Europe at the close of the Glacial Period," etc. (Royal Soc. Proc. March 9, 1893).

Since Professor Prestwich's retirement from the Oxford Chair, in 1888, he has mostly resided at his country seat, Darent Hulme, Shoreham, Kent, a charming house built to his own taste some 25 years ago, full of quaint geological pictures by Ernest Griset; and even in its architecture illustrating geology at every turn. Here he divides his time between his garden and his library, always in association with Mrs. Prestwich, his ever-constant companion and most enthusiastic scientific friend, adviser, and co-worker, the beloved niece of the late Dr. Hugh Falconer, F.R.S. H. W.

II.—On Fossils applied as Charms or Ornaments.

By The Editor.

THE summer visitor to Lyme-Regis, to Scarborough, or to Whitby, is familiar with the little *Ammonites*, mounted in silver as brooches for ladies, and may even have seen them also with heads carved, to represent coiled-up serpents, with green or pink eyes of glass, inserted by the enterprising jeweller.

Doubtless the use of these fossil shells as ornaments has been handed down from Saxon times, when "Whitby's nuns exulting told, * * * * * *

> And how of thousand snakes each one
> Was changed into a coil of stone,
> When holy Hilda prayed."—Marmion, Canto II. xiii.

Nor can it be doubted that the early Rosaries, made from the stem-joints of Encrinites, picked up on the beach, emphasised the fisherman's tradition that:—

> "Saint Cuthbert sits and toils to frame
> The sea-born beads that bear his name."—Marmion, Canto II. xvi.

Many more such legends bearing upon fossils doubtless exist, if one could but gather them up.

My friend Mr. William Cunnington, F.G.S., long since drew my attention to an elegant relic illustrating the belief in the wearing of a fossil fish-tooth as a charm against evil, which prevailed in this

country probably less than three hundred years ago, and as it may interest some of the readers of the GEOLOGICAL MAGAZINE, I give it, with a few prefatory remarks.

The circular enamelled palatal fish-teeth of *Lepidotus maximus*, Wagner (*Sphærodus gigas*, Ag.), from the Kimmeridge Clay of Shotover and Kimmeridge, have long been known over a very wide area of Oolitic country; they are also commonly met with as detached teeth of large size in the rémanié Neocomian bone-bed of Potton, Bedfordshire. Similar enamelled fish-teeth of *Lepidotus Mantelli* from the Wealden are also well-known in many parts of Sussex. Four hundred years ago they had attracted the attention of the learned and the curious and they were regarded as *precious stones*, being called "bufonites" or "toad-stones." This term like those of "serpents-eyes," "chelonites," "batrachites," and "crapaudines," by which they were also known, refers to the vulgar notion that these organisms were originally formed in the heads of serpents, frogs, and toads.

In Dr. Thomas Browne's "Vulgar Errors" (1646), Book 3, chap. xiii., p. 137, the author of that curious work observes:—"As for the stone commonly called a 'Toad-stone,' which is presumed to be found in the head of that animall, we first conceive it not a thing impossible, nor is there any substantiall reason, why in a Toade there may not be found such hard and lapideous concretions; for the like we daily observe in the heads of fishes, as Codds, Carpes, and Pearches, the like also in Snailes, a soft and exosseous animal, whereof in the naked and greater sort [Slugs?], as though she would requite the defect of a shell on their back, nature, neere the head [tail?], hath placed a flat white stone, or rather testaceous concretion.

* * * * * *

"Nor is it onely of rarity, but it may be doubted whether it be of existency, or really any such stone in the head of a Toad at all. For although lapidaries and questuary enquirers affirm it, yet the Writers of Mineralls and naturall speculators, are of another beliefe, conceiving the stones which beare this name to be a Minerall concretion, nor to be found in animalls, but in fields; and therefore Boetius de Boos referres it to Asteria, or some kind of *Lapis stellaris*, and plainely concludeth, 'they are found in fields, notwithstanding that ancient writers pertinaciously affirm that they are produced in the head of the toad.'

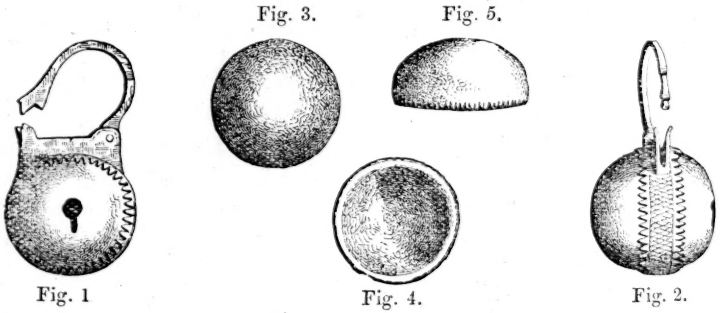
"Lastly, if any such thing there be, yet must it not for ought I see, be taken as we receive it, for a loose and moveable stone, but rather a concretion of the crany it selfe; for (the Toad) being of an earthy temper, living in the earth, and as some say feeding thereon, such indurations may sometimes happen; and thus when Brassavolus after a long search had discovered one, he affirmes it was rather the forehead bone petrified, then a stone within the crany; and of this beleefe was Gesner. All which considered, we must with circumspection receive those stones, which commonly beare this name, much lesse beleeve the traditions, that in envy to

mankinde they are cast out or swallowed down by the Toad, which cannot consist with Anatomy." ✿ ✿ ✿ ✿ ✿ ✿

Extraordinary virtues were attributed to the "toad-stone" in the 16th century; it was held to be a protection against poison, and was often set in rings. That this belief was rife in Shakespeare's time, is shown by the lines in "As you like it," Book II. 1.

> "Sweet are the uses of adversity
> Which, like the toad, ugly and venomous,
> Wears yet a precious jewel in his head."

The following is a transcript[1] of Mr. Cunnington's Note "On a Crapaudine Locket, found in St. John's churchyard, Devizes, by William Cunnington, F.G.S." "In the year 1838, the Rev. E. J. Phipps, the Rector of Devizes, made some improvements in the churchyard. The footpath, which before passed in a very irregular and unseemly manner among the graves, was diverted and carried under the wall to the East. In making these alterations much of the surface was necessarily disturbed and amongst the earth taken from an old grave was found the small locket or padlock, which is represented in the subjoined woodcut.



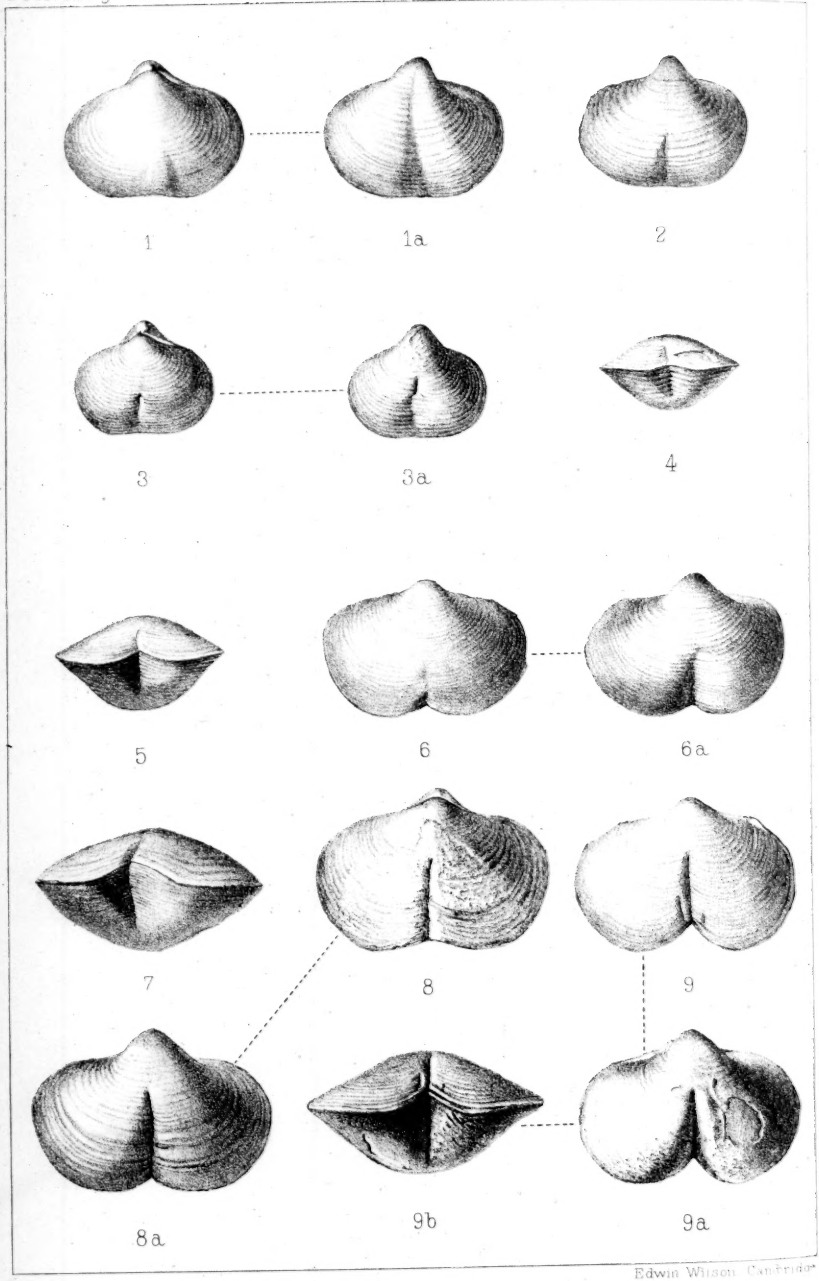
Figs. 1 & 2.—"Crapaudine Locket" (fig. 1, front view, fig. 2, profile), formed of two circular palatal fish-teeth of *Lepidotus maximus*, Wagner, = *Sphærodus gigas*, Ag.

Fig. 3.—Upper and convex outer surface. Fig. 4.—Under and concave inner surface

Fig. 5.—Profile or side view, of a detached tooth of *Lepidotus*.

"It is formed of two of the round smooth (enamelled) teeth of *Sphærodus gigas* (Crapaudines) set together in an ornamental band of metal, to which the loop of the locket is attached. The metallic parts have been well gilded and are in good preservation. The key-hole is cut in the centre of one of the teeth, and some remains of the wards of the lock may still be seen inside. Mr. A. W. Franks, C.B., F.S.A., F.R.S., of the British Museum, has examined the locket, and, judging from the ornamentation, he thinks that it is not of later date than the 16th century. He has never seen a similar object."

[1] I am indebted to the kindness of Mr. W. Cunnington, F.G.S., for the illustration, and to his nephew, Mr. B. Howard Cunnington, of Devizes, for a copy of this paper, extracted from the "Wilts Archæological Magazine," 1870, No. xxxv., p. 249.



ABNORMAL FORMS OF SPIRIFERA LINEATA

III.—Woodwardian Museum Notes.

Abnormal Forms of *Spirifera lineata* (Martin).

By F. R. Cowper Reed, B.A., F.G.S.

(PLATE XI.)

A SERIES of specimens showing successive stages in the development of a remarkable malformation of this species seems to me quite worth recording. The specimens are all from the Carboniferous Limestone of Settle.

The normal and common form of *Spirifera lineata* is well-known; and its varieties—*Sp. imbricata* of Sowerby, Phillips and McCoy, and *Sp. elliptica* of Phillips are likewise constantly met with in the Carboniferous Limestone. The wide gaps between the typical form and its varieties can be bridged over by the examination of a large series of individuals, so that Davidson has grouped these three forms under one specific name.

The variation from the typical form *Sp. lineata* occurs in two directions; first, in the surface ornamentation, by the thickening and widening of the concentric lines on the exterior of the valves, until they become the well-marked flattened lamellæ of Sowerby's *Sp. imbricata*; this change is also accompanied by the production of longitudinal fimbriations which are foreshadowed by fine striæ in some specimens of the typical form.

The second direction in which variation occurs is in the shape of the shell; from subcircular it becomes transversely elliptical; and the surface of the dorsal valve is ridged up into a longitudinal mesial fold, while a corresponding sinus is formed in the ventral valve, as seen in *Sp. elliptica*. There are transitional forms to be found in this case also, showing intermediate characters.

In some species of *Sp. imbricata* I have also noticed a tendency for the shell to become somewhat transversely oval. It is thus clear that in this species there is a great range of variation from the typical form, but in addition to these normal varieties I have recently detected in the Woodwardian Museum a number of specimens showing stages in the development of an abnormal yet nearly symmetrical and regularly occurring deviation. They exhibit the following characters:—

(1) A tendency to become transversely elliptical without acquiring the surface ornamentation of fine striæ found in *Sp. elliptica*.

(2) The development in the ventral valve of a mesial furrow of peculiar form. The normal ventral sinus which sometimes occurs in this species is broad, rounded and shallow, and runs from near the beak to the front edge of the shell, causing a gentle and regular sinuation of the margin.

In these peculiar individuals, however, the mesial furrow commences irregularly as a short indentation, which is continuous and of equal depth, extending in some cases nearly from the umbo to the front margin, or only from the middle of the valve; or it consists of an irregular series of indentations of varying depth; or it exists merely as a slight groove on the anterior border.

In the first stages of development it may assume any one of these forms.

Subsequently the indentation or groove becomes so accentuated as to divide the shell nearly into two lobes.

(3) Concurrently with this modification of the ventral valve, a sharp narrow depression is developed in a very similar manner on the dorsal valve: and this groove increases in depth and joins its fellow on the ventral valve at the anterior margin.

The shells in which this constriction in each valve is strongly developed have consequently a most abnormal shape.

That the malformation is not due to accidents of preservation seems obvious by our possession of specimens showing various and progressive degrees of its development. It seems that an interruption in the growth of the shell must have taken place along the median line of each valve. Whether this was owing to the presence of an internal parasite, or of some foreign body accidentally introduced; or to disease in the mantle; or to the external application of pressure during the life of the brachiopod, is not clear.

In the majority of brachiopods we know that the sinus occurs in the ventral valve and the fold in the dorsal valve, though this fold is occasionally marked by a longitudinal furrow.

But it is interesting to find in *Spirifera Urii* (Fleming) from the Carboniferous, and in the closely-allied *Spirifera Clannyana* (King) from the Permian, a slight indentation in the front edge, and shallow mesial furrows in both the ventral and dorsal valves; these, however, are regularly and symmetrically developed. Still their presence is suggestive.

There are some curious malformations in *Streptorhynchus crenistria*, from the Carboniferous, figured by Davidson in his Supplement to the British Carboniferous Brachiopoda, pl. xxxvii. figs. 4, 5. These likewise seem to be due to interruption in growth, and may be somewhat analogous to that which produced the more symmetrical grooves in the specimens of *Sp. lineata* above described.

A strangely distorted form, named *Streptis Grayii*, from the Wenlock Limestone (figured Dav. Silur. Brach. pl. xiii. figs. 14–22) has its right or left half twisted higher than the other, and consequently both valves are longitudinally divided by a sharply curved line. Were it not for the twisting, this form would closely resemble our abnormal *Sp. lineata* externally.

In a few specimens of a *Terebratula* from the Fullers' Earth of the neighbourhood of Bath in the Woodwardian Museum, indentations occur in both valves of a precisely similar appearance as those in the abnormal *Spiriferæ*; and they seem to have arisen in the same manner.

The exaggerated forms of some bilobed *Terebratulæ* and *Waldheimiæ* and of *Orthis biloba* from the Wenlock Limestone caused Baron von Buch to compare them with one another; and in spite of the great differences of internal structure, Davidson says that similar causes may easily have been at work in each case.

However, I am inclined to hold that in these specimens of *Spirifera*

we have to do not with a specific variation but with an abnormality produced by something interrupting the secreting action of the mantle: whether this was a foreign substance, a parasite, a disease, or a constantly recurring similar accident, I have not sufficient data at present to decide. As far as I know no similar series of forms has been elsewhere described; and in the Woodwardian Museum we have none from any other locality.

EXPLANATION OF PLATE IX.

(The figures are numbered to indicate the successive stages in the development of the abnormal features as exhibited in the series of specimens of *Spirifera lineata* from the Carboniferous of Settle.)

FIGS. 1, 1*a*. Dorsal and ventral aspects. First and earliest stage.
,, 2. Ventral aspect.
,, 3, 3*a*. Dorsal and ventral aspects.
,, 4. Anterior aspect.
,, 5. Ditto. ditto.
,, 6, 6*a*. Dorsal and ventral aspects.
,, 7. Anterior aspect.
,, 8, 8*a*. Dorsal and ventral aspects.
,, 9, 9*a*, 9*b*. Dorsal, ventral, and anterior aspects of the most abnormal specimen.

IV.—On a New Species of *Discites* (*Discites Hibernicus*) from the Lower Carboniferous Limestone of Ireland.

By Arthur H. Foord, F.G.S.; and G. C. Crick, Assoc.R.S.M., F.G.S., of the British Museum (Natural History).

THE specimen which forms the subject of the present communication was obtained by one of the writers from the Carboniferous Limestone, near Dublin. Although one side of the specimen is covered by matrix, yet the other side and the periphery are so splendidly preserved, and the shell has not been distorted during fossilisation, that the characters of the fossil can be accurately determined (see Woodcut, p. 254).

The specimen belongs to M'Coy's genus *Discites*, but differs, so far as we have been able to ascertain, from any species hitherto described.

The shell is discoid, compressed laterally, and composed of rather more than two volutions, which increase rather slowly in diameter. The extreme tip of the shell, possibly a length of about one millimetre but not more, has been broken off in developing the inner whorl from the matrix. The apex is bluntly pointed, and the whorls begin in a wide curve which is free to the extent of about half a volution, from which stage the outer whorl comes in contact with the inner for the rest of the growth of the shell. Thus the young shell to the extent of about half a volution is simply curved.

The transverse section of the free or earlier portion of the shell is subcircular, becoming in the outer whorl subquadrate with the lateral angles rounded. The sides are flattened, and in the second whorl a well-marked, shallow depression occupies the outer half of the lateral area. The periphery is sulcate, bounded on each side by a subangular ridge, and is about one half the width of the side

exclusive of the inner area or umbilical slope. The inner area in the young is convex and imperfectly defined; in the adult it becomes flattened, slopes outwards from the umbilicus and is nearly equal to the periphery in width.

The characters of the septa and suture-lines, as well as the length of the body-chamber, are not known, since the test is preserved over nearly the whole of the specimen.

The entire surface of the free portion of the shell bears well-marked crenulated longitudinal lines; these become less marked as the shell increases in growth and finally disappear. On the inner area they disappear soon after the commencement of the second whorl; on the sides, at the end of the first half of the second whorl; and on the periphery, some at the end of the second third of the second whorl and the rest at the end of the same whorl, *i.e.* at about one-fourth of the whorl from the aperture.

The periphery at the end of the first fourth of the second whorl, *i.e.* at the commencement of the last whorl in the specimen, bears seven nearly equidistant, longitudinal, feebly crenulated lines, one median and three on either side, the outermost on either side being upon the subangular margin of the periphery. The two lines, one on either side of the median line, disappear at about the end of the second whorl, and the rest at about the end of the second third of the same whorl (see *D* in Woodcut, p. 254).

The lateral area at the commencement of the second whorl bears seven nearly equidistant longitudinal lines. Counting from the peripheral margin, the fourth, fifth and seventh lines are crenulated, the rest plain. The third is a very feebly-marked, plain line and soon disappears, leaving at the commencement of the last whorl the wide space between the second and third lines noted below. The seventh line is followed by a plain line which eventually becomes the umbilical margin. Inside this line three other lines are seen, the middle one of the three having just lost its crenulations. The third line appears to occupy the centre of the antiperipheral area, but this point cannot be satisfactorily determined since the whole of this area is not visible at this spot.

At the end of the first fourth of the second whorl, *i.e.*, at the commencement of the last whorl in the specimen, the lateral area bears six longitudinal lines. The two outer lines are very fine and plain; the two next inner are distinctly crenulated; these are succeeded by a fine, uncrenulated, somewhat indistinct line, and then a crenulated line. Then follows the umbilical margin, which becomes more marked as the shell increases in size, and inside this margin is a single feebly crenulated line. The lines on the lateral area are equidistant with the exception of the second and third (counting from the peripheral margin), the space between these being twice as great as the space between any other two adjacent lines (see *C* in Woodcut, p. 254).

The surface of the test especially on the outer whorl is covered by very fine lines of growth, which, crossing the whorls somewhat obliquely backward, curve sigmoidally on the sides, and, becoming

more pronounced at the peripheral margin, make a deep, subangular, backwardly-directed sinus on the periphery.

At the commencement of the last fourth of the second whorl, *i.e.*, at about the half of the outer whorl in the specimen, a constriction follows the course of the lines of growth and probably marks the position of a former aperture; a similar but less distinct constriction occurs at about the end of the first fourth of the last whorl.

A small portion of the test is wanting on the periphery near the aperture, and the underlying cast of the body-chamber presents a roughened surface, the rugosities increasing in size towards the centre of the peripheral area and forming interrupted, feebly-curved lines having their convexity forwards. Doubtless, these are epidermids which reproduce the surface of the mantle at this part.

The dimensions of the specimen are as follows:—

Diameter	72	mm.
Width of umbilicus (between sutures) ...	33	,,
,, ,, (,, margins) ...	about 42	,,
Greatest thickness of last whorl	about 21.5	,,
Height of last whorl at greatest diameter of shell	24	,,
Width of periphery at ,, ,,	10	,,
,, ,, commencement of last whorl	7	,,

The species with which the fossil just described may be compared are *Discites discors*, M'Coy;[1] *Discites discoideus*, de Koninck,[2] sp.; and *Discites compressus*, J. Sowerby,[3] sp.

From *Discites discors*, M'Coy, the shell under consideration differs in having fewer and more compressed whorls, fewer longitudinal lines on the sides, a sulcate periphery with longitudinal lines, and also in the direction of the lines of growth.

It differs from *Discites discoideus*, de Koninck, sp., in being less compressed, in having fewer whorls, the longitudinal lines on the lateral area crenulated, and in having longitudinal lines on the periphery.

Discites compressus, J. Sowerby, sp., has more compressed and more numerous whorls, a nearly smooth shell and the longitudinal lines on the lateral area do not reach to the end of the first whorl. Its umbilical margin is more angular and its periphery more concave.

We therefore propose to regard the specimen as representing a new species and to call it *Discites Hibernicus*. Its specific characters may be stated as follows:—

Discites Hibernicus, sp. nov.

[non *Nautilus Hibernicus*, d'Orbigny, Pal. univ., vol. i. pl. ci. figs. 2, 3. 1847.]

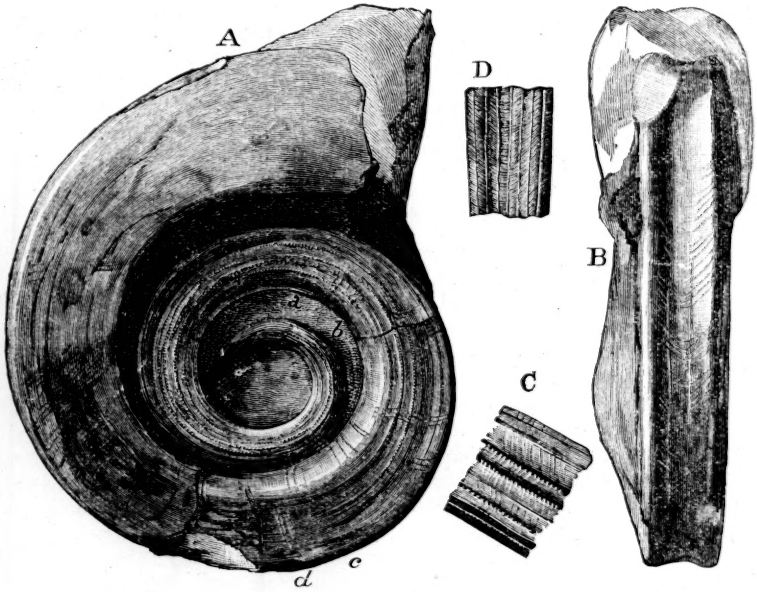
Discoid, compressed; whorls rather more than two; the first half

[1] *Nautilus* (*Discites*) *discors*, F. M'Coy, Synopsis of the characters of the Carboniferous Limestone Fossils of Ireland, 1844, p. 17, pl. iii., fig. 5. See also *Nautilus discors* (M'Coy) L.-G. de Koninck, Faune du calcaire carbonifère de la Belgique (Annales du musée royal d'histoire naturelle de Belgique, Palæont. ser., vol. ii.), part i., 1878, p. 143, pl. xxx., fig. 8.

[2] *Nautilus discoideus*, L.-G. de Koninck, *op. cit.*, p. 133, pl. xxv. fig. 3.

[3] *Ellipsolites compressus*, J. Sowerby, Min. Conch., vol. i. p. 84, pl. xxxviii, 1813. See also *Discites compressus*, A. H. Foord, Cat. Foss. Ceph. Brit. Mus., part 2, fig. 11, pp. 86 and 91. *Nautilus* (*Discites*) *mutabilis*, M'Coy, *op. cit.* p. 18, pl. iii., fig. 7, is a synonym of Sowerby's species.

whorl free, the rest only just in contact; whorl subcircular in section in the young, subquadrate in the adult; periphery convex in the free portion, concave in the last whorl and about one-half of the width of the side exclusive of the umbilical slope; sides flattened; surface of the young shell, also the inner and a portion of the outer whorl ornamented with longitudinal, mostly crenulated, lines; the last whorl bearing backwardly-directed, transverse, sigmoidal lines of growth, which form a deep, backwardly-directed, subangular sinus on the periphery. Septa and siphuncle not observed.



Discites Hibernicus, sp. nov., Lower Carboniferous Limestone, near Dublin.—
A, lateral view of the type-specimen; natural size.
B, peripheral view of the same; natural size.
C, lateral aspect of the portion of the whorl between the letters *a* and *b* in A; somewhat enlarged.
D, the portion of the periphery between the letters *c* and *d* in A; somewhat enlarged.

V.—On the Thickness, Expansion, and Resulting Elevation of Marine Deposits.

By the Rev. O. Fisher, M.A., F.G.S.

WHEN one refers back to such a paper as that by Babbage on the Temple of Serapis at Pozzuoli,[1] one feels humiliated by the little advance which has been made in certain branches of dynamical geology within the last sixty years. That paper contains a full and elaborate account of the plan and history of the Temple and of the remarkable changes of level which its site has under-

[1] Read March 12, 1834; under which date see full abstract in Proc. Geol. Soc. vol. ii. p. 72. For paper in full see Journ. Geol. Soc. vol. iii. p. 186.

gone; and the author speculates among other causes upon the expansion and contraction of the underlying rocks, owing to changes of temperature arising from its being situated in a volcanic district, and he is thence led to speculate on the larger question of the depression and elevation of regions of the earth's surface through the fall and rise of the isogeotherms, caused by denudation and deposition respectively. He concludes his paper (which he had kept by him for many years) with the following sentence: "It may, however, be remarked that, whilst the principles on which it is founded are really existing causes, yet the sufficiency of the theory for explaining all the phenomena can only be admitted, when it shall have been shown that their power is fully adequate to produce all the observed effects."

In this passage Babbage shows his perception of the truth that, while certain known causes may undoubtedly operate in a certain direction, the question of "how much?" must be answered before it can be decided whether the phenomena can be attributed entirely to them.

Without knowing what Babbage had been doing, Sir John Herschel communicated a similar theory about the rise and fall of isogeotherms in a letter from the Cape, dated February, 1836, and sent to Lyell[1] His opinion appears to have been in most respects that which I have myself formulated, namely, that the Earth's crust[2] rests in a state of approximate hydrostatic equilibrium[3] upon a molten substratum. The law of hydrostatic equilibrium is simply, that the weight of a mass floating in a liquid is equal to the weight of the volume of fluid which it displaces. If the crust of the earth was perfectly flexible this law would be applicable to every vertical prism into which it might be supposed divided; but since it is not perfectly flexible we must consider areas which are large in comparison of its thickness, and then, if material were to be denuded off one area, it would rise, because it was lightened, while the area to which the material was transferred would sink, because it was weighted. All the while the effective level of the liquid substratum would not be altered by the mere transfer of material. If the thickness of the crust is only twenty miles, or thereabouts, such an area as the delta of a large river would probably admit of the adjustment taking place: much more might we expect this to occur were the area comparable to that of a continent, or to the seaward extension of the detritus from one.

This being premised, let us now endeavour to find answers to the two following questions of "how much?"—(1) what thickness of deposit under certain conditions could be accumulated in a sea of a given depth? and (2) to what height above the sea-level could the deposit be subsequently elevated owing to the access of heat from beneath?

Let us then imagine a continent bordered by a not very deep

[1] Proc. Geol. Soc. vol. ii. pp. 548 and 596.
[2] Physics of the Earth's Crust, chap. x. 2nd edition.
[3] American geologists have called this "Isostacy."

sea, and that the deposition of sediment has not yet commenced. The isogeotherms under both areas would then be sensibly stationary, and the flow of heat steady under both areas. Next suppose denudation to commence over the continental area, and that sediment is deposited on the sea bottom. The land will begin to rise, and the sea bottom to sink. Whether this goes on equably, or by jerks accompanied by earthquakes, does not concern us now. By the law of hydrostatic equilibrium, the thickness of the deposit possible will depend upon the relative densities of the liquid substratum, and of the crust, which is pressed down into it, because a limit will be imposed by the obvious circumstance that the deposit must cease to accumulate, at least as a marine deposit, as soon as it reaches the top of the water. After this has happened, the detrital matter will be pushed forward beyond the new coast line thus formed, so that on the large scale the entire deposit will have a character of false bedding.

The simple calculations on which the following estimates are based are given in the appended note.

We are obliged to make a guess as to the densities of the crust, and of the liquid substratum on which it floats. I see none more probable than those which I have assumed in my Physics of the Earth's Crust, viz., 2·68 (a fair average for granite) for the crust, and 2·96 (a fair average for basalt) for the substratum. We ought also to know the density of the deposit, which may be put with considerable probability at 2·5, after consolidation. Since the accumulation of the deposit will depress the crust into the substratum, we have to consider whether it is likely that the original crust will maintain its thickness unaltered, or whether some of it will be melted off. It is obvious that on the average the substratum, where it is in contact with the underside of the crust, cannot be able to supply heat to the crust more rapidly than it is carried off by conduction to the surface, otherwise the average crust would be constantly growing thinner, instead of thicker as it must do. Still, if the bottom of the crust was depressed into the substratum, it might be argued that it would reach hotter layers, where it would be melted. But since the heat in a liquid capable of convection cannot become rapidly hotter from the surface downwards, it does not seem probable that much melting would occur from that cause. But on the other hand, the increased thickness arising from the addition of the deposit would retard the flow of heat, and since there is reason to think that the substratum is somewhat above the melting temperature,[1] some thinning of the crust below might arise from this cause. The most probable hypothesis appears to be that, after a sufficient time has elapsed, the action of the substratum will have reduced the new crust, which will consist of the deposit and what remains of the original crust, to the average thickness, that is to the original thickness of the crust at the place in question. But we have in the appended note considered

[1] See the Author's Physics of the Earth's Crust, ch. vi. Prof. Bartoli found the temperature of lava issuing from an underground gallery at Etna, in 1893, to be 1060° C., and after flowing a mile it was 870° C., and still liquid. This shows that it was above the melting temperature at its first appearing.

these two cases—firstly that in which none of the crust is melted off, and secondly that in which the thickness of the deposit and old crust together is reduced to that of the original crust. The results are that, in the case of none being melted off, the thickness of the deposit which could accumulate, so as just to reach the surface of the sea, would be 4·26 times the depth of the sea. And in the second case, where the thickness of the deposit and old crust together is reduced by melting off to the original thickness of the crust, the depth of the deposit to fill up the sea would be 10·9 times the depth of the sea. These estimates depend upon the densities assumed; but they do not require a knowledge of the thickness of the original crust.

We have next to consider the rise of the isogeotherms produced by the covering, or "blanketing" as it has been called, of the crust by the new deposit, and to estimate the resulting expansion of both. This is the important question started by Babbage, but, so far as I am aware, no estimate has been attempted to be made on the hypothesis of a liquid substratum. In passing it may be remarked that the ascertained fact, that the crust has sunk while being loaded, is a very strong argument for the presence of a liquid substratum.[1]

It is clear that a temperature, perhaps rather above that of fusion, would be maintained beneath the bottom of the crust, and that heat would flow upwards out of the old crust into the fresh deposit; and also out of the substratum into the old crust. Meanwhile the temperature at the top of the deposit would always be that of the sea-bottom, which we may consider to be zero; and the temperature of the bottom of the crust may be taken to be the melting temperature. We shall be sufficiently near the truth if we consider the crust, when under normal conditions, to show a regular increase of temperature with the depth, say one degree F. for 51 feet of descent; and if the deposition of sediment was to cease, an equable rate of increase would after a long time be re-established in the area under consideration, though perhaps with a lower gradient than the normal one on account of a possible increase of thickness of the crust; and the longer the time, the more exactly would this equable rate be attained. Suppose then, for the sake of argument, that the flow of heat was to be held in abeyance until the sea was filled up. The surface of the water being reached, it is clear that no further marine deposit could take place. As soon as this is accomplished, suppose the heat to be free to flow again. Then after the lapse of a long interval the flow will again become steady, and the gradient become an equable one, but until this is accomplished more heat will enter from below than escapes at the surface; so

[1] Astronomers admit this. Professor Newcomb says "We have next to consider the effect of viscosity of the earth. Those geologists who have given special attention to the subject regard it as well established that the earth yields under the weight of deposits as if it were a thin crust floating upon a liquid interior and therefore must be a viscous solid if a solid at all."—Monthly Notices of the Roy. Ast. Soc., March, 1892.

Prof. Harkness of the U.S.A. Navy writes of the plausibility of the theory of hydrostatic equilibrium of the crust in his great work on the Solar Parallax, etc.

that the mean temperature of the whole column will be raised, and it will expand. This expansion, however, will not alter its weight, so that it will continue to float with its base still immersed at the same depth in the substratum as before expansion began. The head of the column would consequently rise above the sea-level, and contribute its share towards the formation of an elevated plateau. It is obvious that the supposition we have made that the flow of heat is held in abeyance will give the height of the plateau too great, because the column will really begin to swell upwards immediately that the blanketing by the deposit commences, and the sea-level will be reached, and deposition cease, sooner in nature than in the case supposed, because what would actually happen would be, that when the deposit had attained such a thickness that the expansion going on during its deposition had brought it up to the top of the water, then no more could be deposited, and it would be only the balance of heat due after that, to make the flow steady and the gradient equable, which would be actually efficient to raise a plateau. In fact, if the rate of deposition were sufficiently slow, it is conceivable that no plateau at all might be formed, the sea being just filled up by the expanded column. It seems therefore probable that coarse deposits, which are more rapidly accumulated, might be raised into higher plateaus than finer ones.

To obtain the alteration in volume due to the expansion, we require to know the melting point of the substratum, and also the coefficient of expansion of rock. Dr. Carl Barus found the melting temperature of Diabase to be about 1100° C. or 2012° F.; while Professors Rücker and Roberts-Austen have determined that of the Basalt of Rowley Regis to be about 920° C. or 1688° F.[1] We shall not be very far wrong therefore if we put the temperature of the substratum at 2000° F. The coefficient of the expansion of rock has been investigated by several experimenters, and for the voluminal expansion may be taken as 0·0000215 for 1° Fahr.

In the appended note a simple expression is found for the voluminal expansion of the column, consisting of the new deposit and the old crust, after the flow of heat has become steady and the gradient again equable. In the first case examined, when there is no melting off at the bottom of the old crust, the expansion would be 0·09 of the original depth of the sea. Thus, if the sea were a mile deep, the expansion of the column would be 475 feet.

In the second case, where the thickness of the deposit and what remains unmelted of the original crust is supposed equal to the original thickness of the crust (which seems probable), the expansion has been found in terms of that thickness and the depth of the sea. Thus, if the crust were twenty miles thick, and the original depth of the sea were one mile, the expansion of the column after the sea was filled up would be 1800 feet.

The amounts of expansion obtained here are voluminal. And considering that lateral expansion would be prevented by the adjacent

[1] See "Appendix to Physics of the Earth's Crust," p. 19.

parts, it seems proper, as we have done, to assign the whole to vertical elevation. Whether this was accompanied by crumpling or not would not affect the amount of elevation; but, seeing that the horizontal expansion at any given depth would be only one-third of the voluminal expansion at that depth, there could be but very little crumpling at any given place in the rocks, and there seems no means by which the crumpling could be localized.

Our estimates, as already explained, have been made on the hypothesis that the expansion of the column does not commence until the sea has been filled up, instead of the two processes going on together, as in nature they would do; so that the rising sea-bottom would meet the falling sediment, and the sea get filled up with a less thickness of deposit, while only the balance of heat still required to make the flow steady, acting upon a less thickness of deposit than we have estimated, could be appealed to for the elevation of the plateau.

A depth of 1000 fathoms is the limit of what Mr. Murray calls the Transitional area of the ocean;[1] all beyond being classed as abysmal. It seems, then, that a mile is an excessive depth for the application of our calculations.

On the whole our results do not appear to be favourable to the theory that elevated plateaus, and still less mountain ranges, can have been produced by the expansion of deposits owing to the consequent rise of isogeotherms, and that we must look in some other direction for the efficient causes of those features. What the writer believes these to be, will be found in chapter xxiii. of his "Physics of the Earth's Crust." To describe them here would expand this paper to an undue length.

NOTE.

FIG. 1.

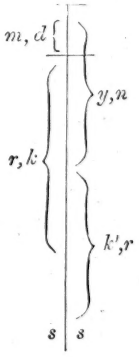
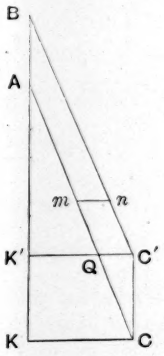


FIG. 2.



[1] "On the Height of the Land and Depth of the Ocean," Scottish Geographical Magazine, vol. iv. Jan. 1888.

To find the thickness of deposit which, irrespective of expansion, would raise the sea-bottom by a given amount.

(Fig. 1.)

Let d be the height to which the sea-bottom is raised, k the original thickness of the crust, r its density, s the density of the liquid substratum, m the density of the sea. Let y be the thickness of the deposit, n its density; $k'=k-x$ the thickness to which the original crust is reduced by melting off at the bottom.

Then we have by the conditions of hydrostatical equilibrium,

$$md+rk+s\ (y+k-x-d-k)=ny+r\ (k-x)$$

whence—

$$y=\frac{s-m}{s-n}d+\frac{s-r}{s-n}x. \quad (1)$$

It may be noticed that the original thickness of the crust k does not appear in this expression.

When d is equal to the original depth of the sea, the sea will have been filled up, and the deposition must come to an end at that place. Let us then find the thickness of deposit which would fill up the sea under two conditions.

First suppose there is no melting off. Then $x=0$, and the possible thickness of deposit will be,

$$y=\frac{s-m}{s-n}d. \quad (1)$$

where d is the original depth of the sea.

Secondly, suppose that there is melting off. Then when d and x have both of them attained their greatest values, y will cease to increase. It is evident that the greatest value of d will be the original depth of the sea. We may conclude that, when the deposit and what remains unmelted of the original crust have been reduced by melting to the thickness of the original crust, no further melting will take place; and this will correspond to the greatest value of x. Then we must have,

$$y+k-x=k.$$

$$\text{or } x=y.$$

Substituting y for x,

$$y=\frac{s-m}{s-n}d+\frac{s-r}{s-n}y.$$

$$\text{or } y=\frac{s-m}{r-n}d. \quad (2)$$

which gives the final depth of the deposit, d being here also the original depth of the sea.

We can now make some probable numerical estimates.

Let us take, as explained already, $s=2{\cdot}96$, $r=2{\cdot}68$, $m=1$. For the density of the deposit we may fairly assume $n=2{\cdot}5$. With these values, if none of the crust is melted off, since $\frac{s-m}{s-n}=4{\cdot}26$, the greatest thickness of deposit will be 4·26 times the depth of the sea.

If we make the second supposition, that the deposit and the unmelted crust maintain the original thickness of the crust, since $\frac{s-m}{r-n}=10{\cdot}9$, it appears that the greatest thickness of deposit will be 10·9 times the original depth of the sea. These estimates are necessarily affected by the uncertainty which attends the knowledge of the relative densities. If, for instance, the densities of the crust and substratum are more nearly equal than we have assumed them to be, the possible thickness of deposit in this latter case would be greater.

To find the rise of temperature in the column of the crust and the deposit, and the resulting voluminal expansion.

(Fig. 2.)

Let $AK=k$ be the original thickness of the crust, $AB=y$ the thickness of the deposit and let KC represent the melting temperature t at the bottom of the crust. Then AC will be the temperature gradient at first.

After the deposit has been laid down, and sufficient time elapsed for the flow to have again become steady, suppose $KK'=k-k'$ to be the thickness which has been melted off the bottom of the crust. Draw $K'C'=KC=t$ and then BC' will be the final temperature gradient.

If we draw lines as $m\ n$ parallel to $K'C'$ these will represent the increase of temperature at each depth, and the elementary area, representing the product of any such line with the increment of depth, will represent the product of the increase of temperature into the increment of volume of the column of unit sectional area; and this, multiplied by the coefficient of voluminal expansion E, will give the expansion of that element of the column. Hence $E\times$ the sum of such elementary areas will give the expansion of the whole column: that is

$$\begin{aligned}\text{Expansion of the column} &= E \times \text{area } B\,A\,Q\,C\\ &= E(B\,K'\,C'-A\,K'\,Q)\\ &= E(\tfrac{1}{2}\,B\,K'\times K'\,C'-\tfrac{1}{2}\,A\,K'\times K'\,Q)\\ &= E\left(\tfrac{1}{2}\,(y+k')\,t-\tfrac{1}{2}\,k'\,\frac{k'}{k}\,t\right)\\ &= E\left(y+k'-\frac{k'^2}{k}\right)\frac{t}{2}. \qquad (3)\end{aligned}$$

If we suppose that there is no melting off at the bottom of the crust, then k' and k are equal, and the expansion becomes $E\,y\,\frac{t}{2}$.

Taking $E=0{\cdot}0000215$, $y=4{\cdot}26d$, and $t=2000°$ F., we obtain for the expansion of the column $0{\cdot}09\,d$; so that, if the sea was a mile deep, the expansion of the column subsequently to the sea being filled up would be 475 feet.

If we make the supposition that the thickness of the crust which

remains unmelted together with the deposit are equal to the original thickness of the crust, then

$$y+k'=k.$$

or $$k'=k-y.$$

Substituting this for k' in the expression for the expansion we obtain

$$\text{Expansion} = E\left(yt - \frac{y^2}{k}\frac{t}{2}\right)$$

Under the now supposed circumstances we have seen that $y=10{\cdot}9\ d$. If then we take the crust to have been originally 20 miles thick, this gives

$$\text{Expansion} = E\left(10{\cdot}9\ d \times 2000 - \frac{(10{\cdot}9\ d)^2}{20}1000\right).$$

Hence if the sea was a mile deep at first.

$$\text{Expansion} = 0{\cdot}0000215 \times 15860 \text{ feet},$$
$$= 1800 \text{ feet}.$$

It can be shown by substituting for y and k' in (3), and differentiating with respect to x, which measures the melting off, that the greatest expansion will take place when

$$x = \tfrac{1}{2}\left(\frac{s-n}{s-r}+1\right)k,$$
$$= 0{\cdot}8\ k.$$

This is a greater amount of melting than is probable.

VI.—Notes on the Devonian Fishes of Campbelltown and Scaumenac Bay in Canada,—No. 3.

By R. H. Traquair, M.D., F.R.S., F.G.S.

Fishes from the Upper Devonian of Dalhousie, Scaumenac Bay.

Ctenodontidæ.

Scaumenacia curta (Whiteaves).

Phaneropleuron curtum, Whiteaves, Canad Nat. n.s. vol. x. p. 21, also in Trans. Roy. Soc. Canada, vol. iv. sect. iv. p. 108, fig. 2, and vol. vi. sect. iv. p. 91, pl. v. fig. 3. A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. ii. p. 248.

MR. WHITEAVES in his description of this species mentions that "in one specimen there are indications of what looks like a short break or separation between the anterior and posterior portions of the dorsal (or between the two dorsals if there were two, which is scarcely probable), but this break may be owing to an accidental and abnormal fracture of the fin rays at this point, for in other specimens the two portions appear to be continuous." This break is, however, represented in all his figures, including the restored sketch given in his second paper in the Transactions of the Royal Society of Canada.

But on looking carefully through the whole of the extensive series of this species collected by Mr. Jex last summer and also on

re-examining the specimens already in the Museum, I find that there is no doubt whatever, that in all of them the dorsal fin is in two distinct portions, which are separated from each other by a very perceptible interval.

The anterior dorsal commences far forwards; it is low and fringing in character and the length of its base is contained two-and-a-half times in that of the posterior dorsal, the interval between the two fins being equal to one-third of the length of the base of the anterior. The base of the second dorsal extends to a point a little beyond the commencement of the lower lobe of the caudal, but as its rays are long, and the posterior ones directed nearly horizontally backwards, the fin seems to extend near to the tip of the tail. It does not, however, form a continuous dorso-caudal as in *Phaneropleuron*, as hitherto described, or in *Ceratodus* or *Uronemus*, and Mr. Whiteaves is certainly in error in making it do so in his restored figure already referred to. As regards the caudal fin it is in reality *heterocercal*, the upper lobe being represented only by very short rays towards the tip of the body prolongation, while on the ventral aspect the lower lobe is of the triangular form characteristic of Dipterus. Indeed, the resemblance of the fins to those of *D. macropterus*, Traq., from John O'Groat's, is very remarkable, the most striking difference being the more extended base and fringing form of the anterior dorsal in the species under consideration. *Dipterus Valenciennesii*, *D. macropterus* and *Scaumenacia curta* form then a complete and most interesting series as regards the configuration of their dorsal fins; in the first both dorsals are short based, in the second the posterior dorsal has a base of considerable length, in the third the anterior dorsal is long based, while the base of the posterior one is still longer than in the second.

The question here arises,—what is the condition of the dorsal fin-arrangement in the typical *Phaneropleuron Andersoni*, Huxley?—for on that depends the validity of the new genus which I propose, provisionally at least, to institute for the reception of Whiteaves's *Ph. curtum*. In the Dura Den fish the dorsal fin was originally described by Huxley, and afterwards by myself, as continuous anteriorly, and if that description holds good *Ph. Andersoni* occupies the fourth place[1] in the series of dorsal fin differentiations, and the Canadian species is also generically distinct. The specimens of *Ph. Andersoni* in Edinburgh or even in the splendid collection of Dura Den fishes at St. Andrew's are not sufficiently perfect in the region to afford a decided answer, and I regret that since this question came under my notice, I have not had the opportunity of re-examining those in the London collections, though here it must be noted that Mr. Smith Woodward, in his catalogue of the Fossil Fishes in the British Museum, pt. ii., p. 247, states that the dorsal fin of *Phaneropleuron* is "single," and it certainly appears to be so represented in Huxley's figure of the finest specimen of *Ph. Andersoni* in that Museum. I feel therefore justified in provisionally erecting the

[1] As a matter of evolution the series would of course be reversed, *Phaneropleuron* being first and *Dipterus Valenciennesii* last.

Canadian species *curtum* of Whiteaves into a new genus characterised by its double dorsal fin, and for which the name *Scaumenacia* may be proposed.

Mr. Smith Woodward has recently pointed out[1] that in curt the proximal interspinous elements (axonosts) of the anal fin are as in the second dorsal of *Eusthenopteron* and *Tristichopterus* fused into one piece which is followed by three distal elements (baseosts). This is well shown in the present series of specimens, but in one splendid example, wanting the head it is true, but which originally must have been over two feet in length, it is also shown that a third and additional set of ossicular fin-supports followed on the second, though they are ordinarily concealed by the bases of the fin-rays.

Classification.—Although the Dipnoan affinities of *Phaneropleuron* were certainly indicated by Huxley in his "Essay on the classification of the Devonian Fishes," he placed the genus among the Crossopterygii in a distinct family of "Phaneropleurini" which he thus defined:—

"Dorsal fin single, very long, not sub-divided, supported by many interspinous bones, scales thin cycloidal, teeth conical; ventral fins very long, acutely lobate."

To this family I afterwards added the Carboniferous *Uronemus*, but the cranial structure and dentition of both genera were then very imperfectly known.

Cope was, I believe, the first who boldly relegated *Phaneropleuron* to the Dipnoi; but the thing was beyond all doubt when Whiteaves showed that his *Phaneropleuron curtum* was possessed of a ctenodont dentition and an arrangement of cranial plates resembling that in *Dipterus*. That the same points hold good for *Phaneropleuron Andersoni* there cannot be any doubt, and as for the conical marginal teeth, described by Huxley, I have satisfied myself that they are merely the outer denticles of ctenodont plates. Whiteaves's statement that in *Scaumenacia curta* "both the upper and under jaw are armed with smooth conical and somewhat compressed teeth" I have never been able to confirm—at least if "marginal teeth" are hereby meant. Consequently, putting aside the older but less suitable name of Ctenododipterini (Pander and Huxley), I proposed the family term Ctenodontidæ for *Phaneropleuron*, *Ctenodus*, and *Dipterus*, but not for *Uronemus*.

For I had already in 1882 shown that the dentition of *Ganopristodus splendens*, Traq., which I afterwards merged in *Uronemus*, was NOT *ctenodont*; but that on the other hand the anterior part of the palatopterygoid bone, broad and flat, is covered merely by small rounded tubercles, while along the outer margin is one row of laterally compressed, basally confluent, short conical teeth.[2] Such an important difference in dentition seemed to me in 1890 amply to justify the separation of *Uronemus* from *Phaneropleuron* and its allies in a distinct family of Uronemidæ.[3]

[1] Ann and Mag. Nat. Hist. (6) vol. xi. p. 241.
[2] GEOL. MAG. (2) Vol. IX. p. 543.
[3] Proc. Roy. Soc. Edin. vol. xvii. p. 393.

Mr. Smith Woodward, however, in the second part of his Catalogue of the Fossil Fishes in the British Museum, retains the family of Phaneropleuridæ, in which he also still includes *Uronemus*. That *Uronemus* must, on account of its non-ctenodont dentition, be placed in a different family from *Phaneropleuron* is, as I have above stated, perfectly clear to my mind at least; for the rest, the Phaneropleuridæ are separated from the Ctenodontidæ, according to Mr. Woodward's definition, by the possession of marginal teeth and of jugular plates. As regards the former character I believe it to be founded on a mistaken interpretation; as to the latter, are we quite sure that we know the structure of *Ctenodus* sufficiently well to be able to decide with certainty as to whether it had jugular plates or not?

Mr. Woodward also erects a separate family for *Dipterus*—that of the Dipteridæ, the essential characters of which, as distinguished from those of the Phaneropleuridæ, are: the absence of marginal teeth, and the heterocercal configuration of the tail, this form of caudal fin along with the possession of jugular plates distinguishing it from the Ctenodontidæ. It is not necessary to repeat what has been said as to the marginal tooth question; as regards the heterocercal tail in opposition to the diphycercal form, if we accepted that as a family character in the Crossopterygian fishes we should separate genera which otherwise are most closely allied. Take the Rhizodontidæ for example,—in *Rhizodopsis* the tail is heterocercal, in *Gyroptychius* as nearly as possible diphycercal; so in like manner the most marked distinction between *Tristichopterus* and *Eusthenopteron* is the decided heterocercy of the former and the nearly perfect diphycercy of the latter. But the median fin-system of *Scaumenacia* is connected by so perfect a transition through *Dipterus macropterus* to that of the typical *D. Valenciennesii*, that I cannot see how it can be placed in a different family on characters based on those organs.

Consequently I must for the present still consider it the safest thing to include *Phaneropleuron*, *Scaumenacia*, *Dipterus*, *Ctenodus* and their immediate allies in one comprehensive family of Ctenodontidæ, characterised by the possession of numerous dermal cranial roof-plates and a ctenodont dentition.

Coccosteidæ.

Coccosteus Canadensis, A. S. Woodward, Geol. Mag. (3), Vol. IX. (1892), p. 483.

One plate referable to *Coccosteus* and presumably to the above-named species occurs in the present collection. It is the posterior ventro-lateral of the left side, and is peculiar in being narrow posteriorly, and in having the stellate based tubercles with which it is ornamented much coarser than in the typical *C. decipiens* of the Scottish Old Red.

Holoptychiidæ.

Glyptolepis Quebecensis, Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 77, pl. v. fig. 4. A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. ii. p. 336.

The specimen here referred to is the head and anterior part of the body of a large *Glyptolepis*, the only example of the genus in the present consignment of Canadian fishes. It measures nine inches

in length, of which five are occupied by the head. The mandible measures four inches in length; small conical teeth are seen along the dentary margin but the large laniaries are covered up. The free surface of the scales is ornamented with very fine, close, wavy ridges, sometimes irregular or contorted, but mostly longitudinal and tending to converge posteriorily, while they are also often branching and interrupted. In front of the striated portion there is a narrow, semicircular, or crescentic area of small tubercles. The scale-ornament is more delicate than in the Scottish *G. paucidens* and *G. leptopterus*, to which the fish is evidently closely allied.

Here again specific identification is a matter of conjecture, as there are no marks by which it can be positively identified with the small fish described by Whiteaves as *G. Quebecensis*, seeing that it shows neither fins nor configuration of the body, on which characters Mr. Whiteaves's diagnosis was principally founded, while his specimen, on the other hand, did not display the ornamentation of the scales or cranial bones. Mr. Whiteaves mentions, however, the occurrence of two large scales, showing a sculpture resembling that of the scales of *G. leptopterus*, and which he thinks may indicate a second species; he also states that, "it is however possible that they may have belonged to large and adult examples of *G. Quebecensis*, and that the specimen upon which that species is based may be a very immature individual." I accept the latter alternative in the meanwhile, rather than name a new species without sufficient warrant.

Rhizodontidæ.

Eusthenopteron Foordi, Whiteaves.

Eusthenopteron Foordi, Whiteaves, Canadian Nat. n.s. vol. x. 1881 p. 31. Trans. Roy. Soc. Canada, vol. vi. sect. iv. 1889, p. 79, pl. v. fig. 5; pls. vi. vii. R. H. Traquair, Geol. Mag. (3) vol. vii. 1890, p. 17. A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. 2, 1891, p. 362.

The present series of specimens shows the large size attained by this fish, two nearly entire examples measuring respectivly 23 and 24 inches in length, and each would be at least an inch longer were the extreme point of the tail preserved.

Two points I wish to bring forward on the present occasion.

The first is the presence of a small pineal foramen on the top of the skull between the frontal bones, in the very same position as in the Osteolepid genera *Diplopterus Thursius* and *Osteolepis* in which it has been so long known to exist.

The second is the palatal dentition. There is one large palato-pterygoid bone similar to that which I figured nearly twenty years ago in *Tristichopterus*,[1] and which extends from the vomerine region in front to the articulation of the lower jaw behind. Along the anterior two-thirds of the outer margin is articulated, a row of three ossicles bearing the upper laniary teeth, and thus corresponding to the mandibular internal dentary ossicles on which I long ago showed that the laniaries of the lower jaw (except the anterior one) were

[1] Trans. Roy. Soc. Edin. vol. xxvii. pl. fig. 3.

borne in *Rhizodus*. There are two vomers placed behind the premaxillæ, each of which, as in the Osteolepidæ, bears a large laniary tusk. As in the Holoptychiidæ, Rhizodontidæ, and Osteolepidæ in general, the maxilla proper bears only very small teeth.

VII.—The Shell-beds of Moel Tryfaen.

By Prof. J. F. Blake, M.A., F.G.S.

THE idea that the well-known shell-bearing sands of Moel Tryfaen indicate a submergence to the depth at which they are found, cannot perhaps be yet said to be, in the language of Mr. Dugald Bell, "a day-dream of the past," though it is fast becoming so. Towards this result there must be two stages—disbelief in the submergence, and belief in something else. As to the first, Sir A. Ramsay wrote—"He must be a bold man who could see the shell-beds at Moel Tryfaen and deny that the sea had been there." I remember quoting this to my much lamented friend Prof. Carvill Lewis and receiving for reply, "one has to be bold sometimes if one would come at the truth." For my own part the result of seeing them for the first time would be expressed in Sir A. Ramsay's words with one alteration only—the substitution of "affirm" for "deny," so that with me the first step was soon taken. The second step is somewhat more difficult if we want to get a clear idea of the method of the transport of the shells, and being recently at the spot, on other business, I thought it might be well to note some of the details which must guide us to a right explanation, but which do not appear to have been as yet very particularly noted.

In the first place the supposed difficulty of getting the "Irish Sea glacier" to so great a height is not one which would have troubled Sir A. Ramsay, nor any one else who knew the district; it is a mere question of a couple of hundred feet, for if ever there was a glacial moraine where no ice is now, it is on the west side of Moel Tryfaen. Indeed there are several. Coming up from the level of the Gwyrfai River, we pass over three well-marked long mounds, the highest one having the steepest slope and looking from the lower ground like a long range of hills. These all run parallel from about N.NE. to S.SW. and they are all composed of the most typical moraine stuff and crowded with huge stones of which many are granite absolutely unknown in Wales, and other rocks which must have come across the sea, with occasional masses of Carboniferous rocks, limestone, and sandstone, only derivable from Penmon, a thousand feet below their present level. That such mounds as these could be the droppings of icebergs never did and never could enter the head of Sir A. Ramsay, who recognized them as certain proofs of a huge glacier or ice-sheet that had crossed the Irish Sea and of which they were the terminal (or perhaps the lateral) moraines. Now the summit of the highest of these long ridges is 1100 feet above sea-level. If the glacier could rise as high as this, it would be a small matter to rise a little more. It was only the presence of the sea shells which led to the belief that after the glacier had disappeared, the land had

been submerged, not locally, so as to reduce the relative level of these moraines, but over the whole of Wales.

But now comes the real difficulty. The shell drift is on the other side of Moel Tryfaen and the moraines have no direct connection with it. The uppermost and best defined of these stretches in a continuous mound from Braich Melyn Smythaw by Moel Tryfaen village to the slate railway incline. To the E.SE. of this is the high ground of Moel Tryfaen and Moel Smythaw, both of which, on their western slopes, on their summits, and on part of their eastern slopes, are entirely free from drift; and there is only about a quarter of a mile between exposures of live rock on either side of the pass between the two through which the drift could be carried, and this path is at right angles to the trend of the moraine. It is difficult to say whether these hills have ever been glaciated. The temptation to think so is afforded by the great projecting masses of conglomerate which so characteristically cap the summit of Moel Tryfaen, the rest of the hill being of a more generally rounded form. This is so like what we may imagine to be the phenomenon of a *nunatak* that it is hard to resist the idea of its being such. Still we may easily account for it otherwise; for the hardness of the conglomerate resting on softer rocks would be an adequate cause, as in the case of the Brimham rocks of Yorkshire. I am not aware that glacial striæ have ever been found on the upper parts of these hills. There are numerous unrounded crags about on the surface, and the rocks on Moel Tryfaen—where there is a good variety—lie on the surface so accurately in order (now that that order is known) that they must have weathered *in situ* and not have been moved since. So that if ever the ice were there it must have been so long ago that all signs of it have been obliterated and the signs of ordinary weathering have taken their place.

These two hills form part of a long boundary which separates two very distinct glacial areas. Moel-y-Ci, Rhiwwen, Clegyr, Cefn Dui, Moel Smythaw, Moel Tryfaen and Mynydd-Cilgwyn, from a range, on the west of which we find moraine-like heaps with foreign boulders, while on the east the boulders (as far as I have been able to discover, and with the exception of Moel Tryfaen deposits) are not of foreign origin, and the drift is not spread out in the form of moraines. I take it that these hills stood like outposts to the North Wales camp in glacial times and forbad the invader to overstep their lines.

The nature of the problem to be solved must now become evident. How is it that these shelly deposits have found their way within the North Wales line? Why do we find within this area a deposit which, though not of a moraine-like form, does contain foreign material including shells? And how is it that such deposits are at over 200 feet higher level than the highest of the moraines? For the solution we naturally look to the details of the deposits. These are at present beautifully shewn in the Alexandra quarries, which are being enlarged and the bearing cleared. From 30–40 feet of Glacial beds are exposed, lying on the irregular surface of the slates,

in which there is very little, if any real, terminal curvature. These beds die out and disappear on the slope of the mountain to the west. They equally die out to the south, as seen in the Moel Tryfaen quarry. Towards the east they are not exposed, but the upper part of more clayey drift is thickening in that direction, and probably replaces the shelly. One or other of them is spread out in a fan-shaped mound, forming a feature in the upland valley, and leading on to Hafod-y-wern slate quarries in the Bettws Garmon valley, where perhaps 60 feet of drift with small foreign pebbles is seen sloping down towards the locally glaciated valley. On the eastern margin of this mound there is a great felsite erratic.

In the Alexandra quarries the difference between the shell-bearing sands and the overlying Boulder-clay is well marked, the latter lying in hollows, or in festoons in the former. The Boulder contents of the two do not appear to me to be very different; in both the stones which may be, and probably are, of Welsh origin, are the largest—in the shelly-drifts they are immense—and in both there are smaller (3–4 inch) rounded stones of foreign granite—Criffell, etc. Under these circumstances it does not seem necessary to trouble about the overlying beds; anything special they contain can be easily derived from the shelly-drifts below.

Such are the data we have to go upon, in addition to the well-known characters of the sands and shells. Now when a submergence was assumed as the cause, the foreign pebbles that occur amongst the sand necessitated that the date of that submergence should be after the arrival of the ice-sheet, but if the sands were brought by the ice-sheet itself, they would be the first to come. Starting from the mountains of Scotland, or the Lakes, it would be the *front* of the ice that would first reach the sea, clear it of its loose shells, and carry them forward to Wales. We may therefore safely say that the shell-drifts of Moel Tryfaen are the very earliest of the glacial deposits, other than local, in North Wales, and the shells themselves must have lived in pre-Glacial times. This is quite consonant with the occurrence of the small rounded granite, etc., pebbles in these drifts; they are some of the pebbles of the old Irish Sea, and have suffered little injury at the hands of the ice-sheet. A terminal moraine is the sign of a retreating glacier, hence the long mounds on the west of Moel Tryfaen are the products, not of the advance but of the decadence of ice-sheet; the materials which should be contemporaneous with the shell-drift have been carried away south, and it is just because these shell-drifts have found a corner to rest in, out of the main route, that they have been preserved.

How then did the material get separated from the rest of the moving mass? We might imagine that the sheet came pressing against the northern flanks of Moel Tryfaen, and split in two, leaving the lateral moraine stuff on the eastern side. In this case we should expect to find many angular masses of the conglomerate amongst the *débris*, and that the resisting front of the mountain should be greatly glaciated, neither of which is the case. If this be not the history, then the ice must have come either over Moel Smythaw, or along

the pass between it and Moel Tryfaen. That it came, in part at least, over Moel Smythaw is evidenced, I think, by the great erratic of felsite mentioned above; but our main guide must be the immense boulders of probably Welsh rocks which occur in the sands, together with the still more curious fact of the foreign pebbles in the drift overlooking the Bettws Garmon valley. Both these things point to a commingling of the two moving masses—the Irish Sea glacier and the Welsh Bettws Garmon glacier. They would meet nearly at right angles. This, from the analogy of rivers, we should expect to produce a kind of back-wash, the front of the Bettws Garmon glacier, and the side of the great glacier, would be squeezed out together into the angle between the two. The pressure thus produced would raise this isolated mass of ice to a higher level than either, and force it into a place of rest on the east side of Moel Tryfaen. Here it would ultimately melt, and the contained *debris* would wash down the slopes where now we see them. In this way the great local boulders have been carried all round Moel Smythaw in more than a semicircle, and a similar course has been followed by the small foreign stones on the side of Bettws Garmon. In this way also any riebeckite rock found on Moel Tryfaen may have come round from Mynydd Mawr.

There are, however, to the north of this spot several other valleys, as Nant Francon and Llanberis, which should have produced analogous results. Doubtless they did so, but when we examine the area where the back-wash of these should lie, we find it is open country, where they would not be allowed to rest. It is only in the case of Moel Tryfaen that there is a nice little quiet corner, where they could be undisturbed if once they were introduced, and this fully accounts for their being so exceptional.

VIII.—Foraminiferal Limestones from the Grenadine Islands, West Indies.

By A. J. Jukes-Browne, B.A., F.G.S.

THE specimens which form the subject of this note were sent to me by Mr. G. F. Franks, F.G.S., of Bridgetown, Barbados, and were obtained by a correspondent of his from the island of Canouan, one of the Grenadine group. Mr. Franks had made slides from three of the samples, and having recognised them as foraminiferal limestones he sent them to me for fuller examination, stating at the same time that the limestone was associated with a compact igneous rock, apparently a porphyritic andesite, with abundant glassy ground mass enclosing streams of microliths. He also sent fragments of four different varieties of the limestone, and my friend Mr. W. Hill has been kind enough to cut me a slide from one of these which appeared different from the others.

Two of the specimens are of a light but dull red colour, hard, crystalline and traversed by thin veins of calcite. Slides cut from these two and examined with a one-inch objective showed them to have practically the same structure. They consist of a calcified

ground mass of fine material, full of rounded bodies which can be identified as *Globigerinæ*. All are much altered and are filled with calcite, but in many of them the cell walls can be clearly distinguished; others are so blurred and calcified that unless some were better preserved they would hardly be recognisable. There are also many smaller blebs of calcite which may represent the single spheroidal cells so often found in Chalk and in Globigerina ooze. No other mineral but calcite is discernable, and the rock may be regarded as a fine-grained Globigerina ooze which has undergone partial marmarosis.

A third specimen is a compact and crystalline grey limestone, in which many minute specks of iron-pyrites can be distinguished with the unaided eye. Under the microscope it is seen to contain a much greater variety of ingredients than the limestone above described. *Globigerinæ* are very numerous and in a better state of preservation, the cell-walls being quite clear and distinct, but with them are some larger Foraminifera, chiefly *Amphisteginæ*, and a few which appear to be small *Nummulites*, and one or two nautiloid forms. There are also many fragments of a clear yellowish mineral which appears to be glauconite; but differs somewhat from the green glauconite of our own Cretaceous rocks. The grains are of irregular and often angular shapes and some of them seem to be entangled with crystals of calcite; such grains polarize in patches which change from yellow to dark-grey, while parts remain clear and yellow, as if the original mineral had undergone some partial kind of alteration. As, however, the same yellowish mineral is seen filling some of the *Globigerinæ*, I think it may be regarded as glauconite, and Mr. J. J. H. Teall, F.R.S., to whom a slide was submitted, concurs in this opinion.

Scattered through the slide are many very small cubical crystals of an opaque mineral, which is evidently the iron-pyrites visible in a hand-specimen.

The fourth sample is also a compact crystalline grey limestone, similar in general aspect, but without any pyrites. Under the microscope further differences are apparent; there are no *Globigerinæ*, the rock being chiefly made up of *Amphisteginæ* and *Nummulites*,[1] with a few others which resemble Cristellaria in section and some fragments of shell. Mingled with them are grains and patches of a yellowish glauconitic mineral occurring in the same way as in the specimen just described. There seems to have been a little greyish mud between the Foraminifera, but it does not occupy so much of the field as the latter do, and the interstices are filled up with crystalline calcite.

The interest of these limestones is (1) their occurrence in the Grenadine group, which was supposed to consist entirely of igneous rocks, and (2) their similarity to rocks which occur in Trinidad and Barbados. Barbados lies about 120 miles to the E.NE. of Canouan, and San Fernando, in Trinidad, is about 170 miles away to the southward.

[1] For the identification of these genera in the slide, I am indebted to Dr. G. J. Hinde, F.G.S.

The Globigerina Limestone might be an indurated chalk of Barbadian type, but it can also be compared with the Globigerina marls recently described by Mr. Lechmere Guppy,[1] and its association with a rock containing shallow-water forms, such as *Amphistegina* and *Nummulites* is a fact which specially recalls the San Fernando section, where a certain band of limestone is said to consist chiefly of *Amphistegina* and *Nummulites, Rotularia clymenioides* and Nullipores.[2]

The San Fernando beds are considered to be of Eocene age by Mr. Guppy, and if Eocene is used in its older Lyellian sense as including all that is older than Miocene, he may be right; but the classification of the Tertiary deposits of the West Indies is at present in a very unsatisfactory state. It is at any rate interesting to find in this small patch of limestone on Canouan what seems to be evidence of the northerly extension of the sea in which the Foraminiferal deposits of Trinidad were accumulated.

IX.—Note on the Tuscan Archipelago.

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., A.M.I.C.E., F.C.S., F.G.S.

In the course of a recent prolonged residence in Tuscany and the Carrara Marble District, I had occasion to become well-acquainted with the Maremma hills and the islands composing the Tuscan Archipelago; and as I propose to revisit those islands at an early date with a view to more closely examine certain phenomena relating to the eruptive and metamorphic series more especially of Elba, it may not be out of place if, in the meantime, I give a rapid preliminary sketch of the leading geological and petrological features of that archipelago as a whole.

As is well-known, the exceedingly interesting but also extremely complex phenomena which are met with more especially in Elba have, apart from the mineral wealth of that island, for many years attracted the attention not only of Italian, but also of other geologists such as Vom Rath, Rayer, Dalmer, Nessig, and others. In not a few cases, however, the more or less cursory inspection on the spot by some, and the one-sided microscopical examination of a few isolated and hence not representative specimens by others, have led to a variety of conflicting and not infrequently erroneous views. The recent survey of the island, made on behalf of the Italian Government by Signor Lotti and his coadjutors, is therefore the more welcome, as at any rate a modern and adequate geological map of that classic locality is now available as a basis and starting-point for further research.

It need hardly be pointed out that the Tuscan Archipelago not only constitutes the connecting link between the mainland of the Italian peninsula and Corsica and Sardinia, but also forms part of the chain of islands which fringe the whole length of the peninsula as far as Sicily, and whose eruptive phenomena in more ancient as well as in

[1] Quart. Journ. Geol. Soc. vol. xlviii. p. 519.
[2] *Op. cit.* p. 523.

recent geological epochs have been both the cause and the effect of great changes no less on the mainland of the peninsula than in the Mediterranean itself.

The islands composing the Tuscan Archipelago, and situated, roughly speaking, at about thirty miles from each other, are Gorgona, Capraja, Elba, Pianosa, Montecristo, Giglio, and the promontory, practically also an island, of Argentario.

The most ancient rocks of the Tuscan Archipelago are the pre-Silurian schists and serpentines of Gorgona, Giglio, Argentario and the eastern part of Elba, bearing analogy not only with the same series of Sardinia and the north-eastern part of Corsica, but also generally with the Archean and Cambrian series of the Alps. In the eastern part of Elba, these schists and serpentines underlie the Upper Silurian fossiliferous schists, and although Dieulefait refers the Corsican serpentines to Trias, or at all events declines to accord them a greater age than Permian, their analogy with the Elban rocks stamps them as undoubtedly pre-Silurian.

The rocks overlying the Upper Silurian strata in the islands of Giglio, Argentario, and also in the Maremma hills, have been referred to Permian from their analogy with the schists of Monte Pisano, the highest peak of the Carrara mountains where Permian fossils have been found.

Of the secondary formation, Trias is conspicuous by its absence in the whole of the Archipelago, and Infralias, which is also represented in the Maremma hills and in Corsica, rests directly not only

on the Permian, but also on the Silurian and pre-Silurian rocks. The Lias series is represented in Elba but not in the other islands, and gives evidence of another remarkable break, inasmuch as it overlies directly the Permian and even the pre-Silurian strata. The Upper Lias comprises the metamorphic rocks, felsitic schists, and compact and crystalline limestone with garnet and Wollastonite, which are met with on the summit of Monte Cappane, the highest point of Elba, where they overlie the granite. Upon the Upper Lias strata follow immediately the Eocene rocks, thus marking another characteristic gap which is also conspicuous in Corsica as well as in the Maremma hills. Indeed in Elba, the Eocene strata rest not only on the Lias, but also direct on the pre-Silurian formation. They comprise in upward series, nummulitic schists, red, green, and grey limestone, followed again by nummulitic limestone, limestone, schists and sandstone, with numerous and extensive dykes of serpentine, gabbro, and diabase. The Eocene serpentine frequently appears in close proximity to the ancient serpentine, from which it is easily distinguished alike by its different texture and location. It is a characteristic feature that the Eocene serpentine, gabbro, and diabase of undoubtedly igneous origin always occur together in the same superposition. The Upper Eocene strata are traversed by great viens of porphyritic granite, and the fact of these strata having been proved to be nummulitic and hence Eocene proves the further important fact that the intrusive Elban granite, which has been so fruitful a source of controversy, is neither trachyte, nor liparite, nor felsitic porphyry as it has been called by some petrologists, but is a true tourmaline-bearing porphyritic granite of Tertiary age. Moreover, the same intrusive granite occurs under analogous conditions in the islands of Montecristo and Giglio, as well as on the mainland in the Maremma hills.

Of the metalliferous deposits of Elba, some are found in the pre-Silurian, others between the Permian and the Liassic, others again between the Permian and Infralias strata, while the workable deposits of oxide of iron and the limestone and siliceous rocks with which they are associated, are younger than the Eocene sedimentary and intrusive rocks already referred to. The Miocene and Pliocene strata are absent in the Archipelago with the exception of Pianosa, where they bear close resemblance to the Corsican rocks of the same age. The post-Tertiary formation is represented in Elba, Giglio, and Pianosa by a coarse calcareous sandstone and a conglomerate with marine-shells, which in part edge the coast and in places reach a depth of over 600 feet above sea level. The andesites of Capraja probably erupted during the same period.

It is thus seen (1) that the islands of the Tuscan Archipelago are, geologically and petrologically, closely connected, not only with each other, but with the Maremma hills on the one hand, and with Corsica and Sardinia, as well as with the Ligurian Alps on the other; (2) that, therefore, they probably constitute part of a former Tyrrhenian continent; and (3) that as a whole, and with a few significant exceptions, they are representative of every geological

formation from the pre-Silurian downwards, irrespective of the exceedingly interesting eruptive series, which it is not the purpose of this preliminary notice to discuss.

X.—Was the Deposit of Flint and Chalk Contemporaneous?

By G. Abbott, M.R.C.S.

MANY difficulties remain to be solved and much work to be done before we rest satisfied that we can understand how flint took the peculiar shapes and position in which we find it in the Cretaceous strata.

Most geologists will now agree with me that we must look to the action of segregation for the explanation. The older theory of colloid silica, as well as that of the chemical replacement of the organic matter in the sarcode of sponges by silica, long held sway, and even yet their influence is to be traced in the most recent literature on the subject.

To advance our knowledge and to obtain a working hypothesis at once accurate and comprehensive, ought we not to commence by trying to find out *when* the silica was deposited? Did it take place before or after the Chalk was raised above the sea-level?

Many writers imply, if they do not state, that the formation of flint took place contemporaneously with the deposit of the chalk strata. With this I disagree; anyway it seems of the utmost importance that this point should be inquired into, for manifestly the influences at work to effect the chemical changes would be quite different in the two cases.

The *tabular* flint of the Upper Chalk appears to give us some valuable data with regard to this point.

During the last twelve months I have examined all the specimens I could find, many *in situ*, and they all showed signs of having "grown" in faults.[1] Besides being found in the position where one would expect to find such fissures, they show innumerable traces of having been formed of two plates originally distinct, but which by the gradual addition of silica have approached each other and united into one thick tabular mass. Few specimens fail to show where this junction took place, whilst here and there irregular cavities remain, due, I presume, to the process in that portion being incomplete when segregation ceased.

The thickness of these tabular flints varies considerably—ranging from $\frac{1}{4}''$ to 6″ or more, sometimes almost reaching these extremes within the space of a foot, but more often lying for long distances between fairly parallel walls. The external surfaces correspond to those of the broken chalk, having here and there excrescences which indicate the growth of flint in cavities on the walls of the fissure, the surfaces in some specimens being so angularly rugged that the Chalk must have been dry and hard when the fissure occurred.

I have looked for, but hitherto have failed to find, any other satisfactory explanation of these remarkable dyke-like deposits.

[1] This can hardly apply to the continuous *horizontal* layer of flint which occurs in the Chalk from Thanet to Dover.—Edit. Geol. Mag.

If, however, we may use this as a working hypothesis that tabular flints "grew" by gradual accretion and quite independently of any organic agency, can we any longer believe they were formed even partially when the Chalk was beneath the sea. The upper part of the Chalk would then have been in the condition of soft ooze, and even if cracks were formed, the spaces would have been quickly filled with cretaceous matter and the deposit of flint rendered impossible owing to the length of time it would have taken to "grow" on the walls of the cleft.

Very much of course depends on the settlement of this question. Will someone point out if it is unreasonable to look in this direction for a solution of our difficulties in reference to chalk flints?

If any of the old theories or even that of segregation *below sea-level* be applied to special forms of flint—paramoudra for instance—they fail to answer even the most obvious questions. The old idea that these potstones originated in cup sponges has been discredited because of the difficulty of understanding how sponges could grow out of one another and extend in great columns like paramoudra, through the height of the cliff. Unfortunately I have had no chance to examine them *in situ*, and therefore only hesitatingly suggest that their origin was entirely independent of animal organisms, they being merely broken pipes of silica which formed in the chalk subsequent to its elevation above sea-level. The silica might have been supplied by the percolation of water through the overlying arenaceous strata, while each section of the broken pipe after its slight displacement by the movement of the Chalk which led to its fracture, would probably still act as a centre for further deposits of flint, and thus all traces of *fracture* would soon be obliterated.

Both paramoudra and tabular flint I believe to have been caused by the deposit of amorphous and crystalline forms of flint in chalk cavities—each by gradual growth extending in the direction of least resistance, without depending upon the help of organic remains, but enveloping and matting together any substances close at hand.

Careful observation of an immense number of other specimens leads me to suggest that in spite of the bossy, irregular forms assumed by flint, it has increased after the same manner as other concretions. This condition is much obscured by the presence of colloidal silica, and has perhaps not been observed because it was not expected or looked for. Instances, however, can be well seen in the interior of hollow flints with cores, supposed to be the silicified casts of the cloacæ of *Siphoniæ*. Although these cores correspond as a rule to the long axis of the cavity, yet there are frequent exceptions. Smaller secondary cores, too, are often present lying at various angles and blending into each other.

It has long been accepted as a fact that flint has often commenced to form in chalk by means of sponges, many of which were subsequently removed after acting as a sort of scaffolding for the flint. This explains the numerous hollow flints met with. To these organisms we must add many others, such as wood, shells, etc., which have acted as centres for the segregation of flint.

Owing to the fact that the addition of fresh silica often destroys all traces of the growth-stages of a flint, very little information can be obtained when the process is complete and the nodule a mere solid mass of flint. Fortunately there are innumerable cases to be found in every stage of development, and those who care to look can find them in most districts of the S.E. of England where the Upper Chalk exists. The absence of flint in our lower beds[1] would of course be explained by the assumption that only half the beds were above the sea-level when the process of segregation was going on.

I may, in conclusion, reduce my suggestions to the following propositions:—

1st. That Flint in the form now found in the Chalk was deposited subsequent to its upheaval above sea-level.

2nd. That whilst the large quantity of siliceous sponge spicules present must have had a considerable share in the formation of the nodular and perhaps the tabular flints, yet quite as frequently various other hard substances and even empty spaces assisted.

3rd. Chalk flints grew after the manner of crystals [or concretions?] and were regulated by similar laws.

Tunbridge Wells.

XI.—Another View of the Submergence of the British Isles during the Glacial Period.

By James D. Hardy.

I QUITE agree with the *submergence* of the British Isles during the last or any Glacial period; but I totally disagree with the theory that there has been any such *depression of the land* as is generally put forward by geologists. Where is the evidence of such depression? Certainly not since Pliocene times, unless the whole of Great Britain sunk and rose simultaneously like the parallel motion of a beam engine. Such a motion would imply not only a surface movement, but also a sinking of all underlying strata. How such a theory ever held for a time is a puzzle to me, excepting the absolute necessity of finding some reason for the sand and shell deposits up to 1500 feet O.D. That the whole of England and at least the greater part of Scotland was covered with water there is evidence enough, and that Britain was not covered with an Ice-cap there is also evidence, if one will look at it free of all old book theories. Geologists—like other specialists—follow their bell-wethers, first in one direction, then in another, and are rarely able to bring other knowledge to bear on their arguments, as I have found when arguing on this depression theory with them.

[1] Mr. David Forbes, F.R.S., pointed out, many years ago, that the Hard Chalk and Grey Chalk really contained an equal quantity of silica as the Upper Chalk with flints, but it had not segregated out into flints in the former as in the latter formation. An excellent account of the Chalk formation and of the Flints and their probable mode of origin will be found in the Geology of England and Wales by Horace B. Woodward, F.G.S. (1887) pp. 397–401. See also paper on Banded Flints by Dr. S. P. Woodward (Geol. Mag. 1864, pp. 145–149, Plates VII. & VIII.), and the Isle of Thanet and its Continuity of the Flint Floorings by F. A. Bedwell, M.A., F.R.M.S. (Geol. Mag. 1874, pp. 17–22, and Proc. Geol. Assoc. 1873, vol. iii. pp. 217–238, pl. iv.).—Edit. Geol. Mag.

What is the evidence with which we have to deal? Beyond the deposits of shell and sand at 1500 feet O.D. there are the remains of glaciers from the Cumberland Hills and Snowdonia—also the Scotch glaciers; of great boulders removed for some miles from the parent rocks, evidently the work of icebergs. Beyond this there are the great masses of Boulder-clays and Crags on the East coast. The Scotch hills bear evidence of Ice action, but not necessarily an Ice-cap—in fact their scorings on the high levels and the *roches moutonnes* of the Lowlands point to moving ice as the cause. Floe-ice probably of great thickness floating away from the higher hills towards the lower—or following the outlet stream.

Now if we look to the South Polar regions, even at the present time, we have quite sufficient evidence to guide us to a proper appreciation of the condition of Britain during the last Ice-age; we see there an accumulation of ice and snow down to the 55° parallel (at least). This is entirely surrounded by water. What is the probable thickness of the ice at the South Pole? Taking an angle of only half a degree at 50° south will give us twelve miles at the Pole. We have only to read Nansen's "Journey across Greenland" to see that it does not require 40° of latitude to give a thickness of ice and snow sufficient to cover the highest hills of that country, but only 1000 miles, though this ice is the remains to some extent, of the last glacial period. We are thus justified in assuming that at the extreme of the glacial epoch, the ice at the North Pole was of the same depth as at the South Pole at the present time. We also find that the level of the water is maintained equally at the edge of both the northern and southern ice. This is the great factor of my theory respecting the conditions presented over England and Scotland. Transposing the positions, we have an ice-cap reaching as far south as the northern part of Scotland *and the water rising level to it.* If the ice-caps at the Poles were 12 miles thick then the water (at $\frac{1}{2}$° angle) would be 2000 feet deep over the central parts of England. This is the submergence dear to geologists, but no depression of land is required. Icebergs breaking away from the edge of the ice-cap would carry any of the boulders we see, and the floe-ice, as the water decreased in depth as the glacial period was passing away, would cause all the scoring and smoothings everywhere observed. The glaciers and moraines express the last of the ice action after the water had left the land, but while it was still under the influence of a cold period.

As I referred to the southern pole as being now under the influence of an ice-cap, it shows that it is not necessary to bring Dr. Croll's theory of the lengthening out of the orbit to cause a glacial period, as the orbit at the present time is as nearly circular as it can be; but that such is simply due to the proportion of winter days to summer days (166 to 199), and the action of the sun on the ice-sheet during the latter term (*vide* Nansen again).

I now come to the *crux* of this argument, viz., the rise and fall of the water. For some years I have been very much puzzled to account for this. It was evident to me that water covered the land; but

where did it come from, and where has it gone? and that so gradually as to lay down our Crags so uniformly—until disturbed by passing ice-sheets; but I have found that it is the nature of the ocean, especially at the Poles, to find its level according to the height of the ice-cap. That some natural law was at work to cause this there can be no doubt, and this is to be found in the *attraction* of the accumulated mass of ice. A continent of ice 5400 miles in diameter, with an average of six miles in thickness above the normal level, must exert a very appreciable amount, especially as this is accumulating at the same time that the ice at the North Pole is losing its attractive power. But we shall have to clear away some of the cobwebs of science—especially astronomical—before men's minds are free and unbiassed enough to approach the consideration of this question from this point of view, so here I must leave it for the present.

REVIEWS.

THE GEOLOGY AND PALÆONTOLOGY OF QUEENSLAND AND NEW GUINEA. With sixty-eight Plates and a Geological Map of Queensland. By ROBERT L. JACK, F.G.S., Government Geologist for Queensland; and ROBERT ETHERIDGE, junior, Government Palæontologist (New South Wales). Published under the authority of the Hon. W. O. Hodgkinson, Minister for Mines, etc., Queensland. Crown 4to. pp. xxx. and 768. Plates 68, and Map of 6 sheets. Brisbane: Beal. London: Dulau & Co., 1892.

TO bring within the compass of a single volume a description of the Geology and Palæontology of such an extensive area as the colony of Queensland must needs involve a great amount of arduous work, and when this has to be accomplished in the intervals of ordinary survey work, there is reasonable excuse for the delay which has taken place in bringing out this volume. As regards the geological portion, the delay has been advantageous in permitting the results of the latest surveys to be incorporated in it, but some of the palæontological investigations have been already anticipated by other authors. In Queensland, as in new countries generally, the portions first examined are those which promise to yield economic minerals, and hence the survey has been carried on in numerous isolated areas, and the geological boundaries of the intervening portions have been determined from the best information available. It will therefore be readily understood that the lines on the map, now published on the scale of 16 miles to an inch, will probably require modification when a more complete survey has been carried out. For the earlier geological work in Queensland we are indebted to the late Rev. W. B. Clarke, Mr. S. Stutchbury, Mr. Aplin, Mr. A. C. Gregory, and more especially to the late Mr. Richard Daintree. Since 1877, when Mr. Jack commenced his work in the colony, the survey has issued no fewer than 88 reports, most of which relate to mining areas.

From the introductory chapter we learn that the Eastern portion of Queensland, comprising from one-third to nearly one-half its area, consists of the remnant of a lofty table-land which reaches an elevation of over 5,000 feet, and from its Eastern edge has a short steep slope to the Pacific. This coast region consists of granites, syenites, basic igneous rocks, and of a series of stratified rocks, which in the lower portions are metamorphosed to a variable extent. The Western interior of the country presents a totally different aspect; for the table-land slopes away gradually towards the Gulf of Carpentaria and the south-west boundary of the colony, and the area consists of soft stratified Cretaceous rocks which form a good soil, though its fruitfulness is marred by a deficiency of rainfall. In some districts there are remnants of table-lands of the so-called Desert Sandstone, which apparently formerly extended over the Cretaceous clays, but fortunately has been largely denuded.

The list of the Geological Formations recognised in Queensland is not nearly so long as that of most European countries, but the authors state that the order of succession bears a general and striking resemblance to that worked out in Europe, though owing to the great distance separating these countries, they do not claim more than a homotaxial relationship for the Queensland formations which they have disposed under European names. Beginning at the top of the series, the post-Tertiary is represented by Bone-Drifts, Cave-Breccias, Sand-Dunes, etc.; in the Tertiary only the Pliocene and Miocene are doubtfully recognized; the former by the Upper, the latter by the Lower Volcanic and Drifts. In the Mesozoic Group, the Desert Sandstone, considered as Upper Cretaceous, rests unconformably on the Rolling Downs of Lower Cretaceous Age. Below these come the Ipswich rocks, forming the Upper Division of the Trias-Jura, whilst the Burrum series constitutes the Lower Division. Then comes in a strong unconformability, and below it the Bowen, Star, and Gympie divisions of the Permo-Carboniferous. Between these and the Burdekin group of Middle Devonian age there is another unconformity. The Burdekin is the lowest Formation containing determinable fossils, below it there are beds of stratified rocks succeeded by slates, schists, etc., of undetermined age.

Successive chapters are devoted to the description of the characters, the economical features, the fossils, and other particulars relating to each of these groups, commencing with the Plutonic and Metamorphic Rocks.

Some of the granites and syenites are stated to be distinctly metamorphic in character; alternate layers of coarser and finer material betraying an originally sedimentary origin. Tin, Silver-lead, Bismuth and Gold mines are present in some of the granite areas.

The metamorphic rocks are considered to have been originally limestones, conglomerates, siliceous and felspathic sandstones, clay-shales and mudstones, which are now generally thrown into sharp folds and locally metamorphosed into marbles, quartzites, greywackes, mica- and talc-schists, lydian stone or even into serpentines, diorites, hornblende and tourmaline gneisses. By Daintree and

others large areas of these rocks were referred to the Silurian and Devonian; but Mr. Jack thinks that there is no direct evidence of the presence of Cambrian or Silurian strata in the country, and that the greater portion of the metamorphic rocks will prove to be of Permo-Carboniferous or Devonian age. Some of the richest Goldfields in the colony, that of Charters Towers for example, occur in the metamorphic areas.

Devonian rocks have been recognized in at least five localities in Queensland. The most important outcrop on the Broken River is sixty miles in length by thirty in breadth. The rocks are mainly limestones, shales, sandstones and conglomerates, apparently forming a continuous series with an estimated thickness of 21,000 feet. These rocks contain a fairly representative series of corals and brachiopods, the species of which are all different from those in the succeeding Permo-Carboniferous Formation. The principal genera of corals belong to *Favosites, Heliolites, Pachypora*, and *Stromatopora*, and the brachiopods belong to *Spirifera, Atrypa, Rhynchonella, Pentamerus* and *Stringocephalus*. Some of the species are identical with those in the Middle Devonian of the Eifel and North America.

The Permo-Carboniferous rocks of Queensland have been ranged under the Gympie Beds, the Star Beds, and the Lower, Middle, and Upper divisions of the Bowen River Coal Field. The Gympie beds are the lowest; they consist of greywackes, sandstones, shales, breccias and limestones, together with volcanic rocks. Gold-bearing reefs are present in some districts, and they prove richest in connection with beds of black shale containing abundant remains of Polyzoa and Brachiopoda. In one shale-bed there are large isolated boulders of greywacke which the author considers to be erratics deposited by floating ice. The Gympie rocks were formerly placed as Devonian, but they are now believed to correspond with the Carboniferous or Lower Carboniferous of New South Wales. Some of the fossils correspond with those in the Middle Bowen Rocks, but there is a large number of species peculiar to each division.

The Star beds occupy a basin of about 36 square miles in extent, inclosed by granite and gneissoid rocks. They have yielded remains of *Lepidodendron, Calamites*, and other plants as well as numerous Brachiopods and Molluscs, some of which are common to the Gympie and Middle Bowen beds.

The Bowen River Coal-field extends from lat. 20° 30′ S. to lat. 26° S. In the lower division no organic remains have been discovered; it is separated from the Middle Division by a series of bedded volcanic rocks. The Middle Division consists of alternations of grey and yellow sandstones and blue and grey shales with occasional bands of ferruginous, probably once calcareous, sandstones. Two seams of coal occur in the series, and in some of the beds of fine sandy and muddy material there are large isolated boulders of granite, which Mr. Jack considers must have been deposited in their present position by ice action. The ferruginous sandstones abound in casts of fossils; in the shales the fossils are less numerous, but better preserved. The Upper Division of the Bowen River series

consists almost wholly of shales and sandstones, probably about 1000 feet in thickness, in which there are numerous plant remains as well as Brachiopoda.

The *Flora* of the Bowen River series has somewhat of a Mesozoic character, for lycopodiaceous plants appear to be altogether absent; in the Middle Division *Glossopteris* is scantily represented, but in the Upper it is abundant. The occurrence of this genus amply confirms the statement that *Glossopteris* was associated with Palæozoic marine beds in New South Wales whatever its stratigraphical position in other countries might be.

The marine fauna of the Bowen River series is distinctly Palæozoic, and its Carboniferous facies can be readily recognized; at the same time a certain degree of relationship to the Permian is shown by the occurrence of forms of *Strophalosia*, *Stenopora*, and large Polyzoa of the *Protoretepora* type, and the resemblance of the *Producti* to the *P. horridus* of the Magnesian Limestone and Zechstein.

Corals are rare in the Permo-Carboniferous of Queensland, and the Rugosa are only represented by a few fragments. The Monticuliporoid genus *Stenopora* is abundant and four species are described. There are three very imperfectly preserved Blastoids, which are doubtfully referred to *Mesoblastus*, *Granatocrinus*, and *Tricœlocrinus*. *Phillipsia* is represented by two species, and there is also one of *Griffithides*. There are several species of *Fenestella*, but only casts of the zoarium are shown. Several species of *Spirifera* are present. Mr. Etheridge adopts the *G. Martiniopsis*, Waagen, for the *Spirifera subradiata* of Sowerby, and the *G. Derbyia*, Waagen, for the *Streptorhyncus crenistria* of Phillips.

The *Producti* are as a rule badly preserved; some of the familiar British forms are present in the Queensland strata, and they appear to be world-wide in their distribution. Species of *Strophalosia* and *Chonetes* also occur. The Pelecypoda are represented by numerous genera, and Mr. Etheridge proposes one new genus, *Deltopecten*, in the family of the Aviculopectinidæ, McCoy, and another, *Merismopteria*, in the family of the Aviculidæ. Several genera of Gasteropods, Pteropods, and Cephalopods are also present, and a few fish remains, doubtfully referred to *Deltodus* and *Palæoniscus*, complete the list.

The Lower Division of the Trias-Jura system, which succeeds unconformably the Permo-Carboniferous, consists of sandstones, shales and coals of the Burrum Coal-field. The age of these beds has been determined mostly by the plants, which show, with the exception of *Sphenopteris*, nothing in common with the plants of the underlying Permo-Carboniferous, but exhibit a strong Mesozoic facies.

The Higher Division of the Trias-Jura, or the Ipswich Formation, occupies an area of 12,000 square miles in the S.E. of the colony, and consists of conglomerates, sandstones, shales, with numbers of coal seams and some limestones. The coal-measures are covered with basaltic lava-flows. The fossils recognizable are almost exclusively those of plants, the only animal remains are a species of *Estheria*, a beetle, and some *Unios*.

The next succeeding Formation, named the Rolling Downs, is placed as the Lower Division of the Cretaceous; it is estimated to cover about three-fourths of the total extent of the colony. It consists of soft, crumbling, dark-grey shales, with bands of sandstone, ironstone and limestone, which rest nearly everywhere in the north of the colony, either on schists of undetermined age or on granite or gneiss, whilst in places it is conformably overlaid by the Desert Sandstone. The series is evidently of considerable thickness, and though mainly of marine origin, plant-beds and coal-seams occasionally occur in it. It is very rich in fossils, which include Foraminifera, Sponges, Brachiopods, Pelecypods, Gasteropods, and Cephalopods. Fragments of the skeletons of *Ichthyosaurus* and *Plesiosaurus*, and specimens of the Mesozoic Ganoid *Belonostomus* have also been met with. Two new genera of the Aviculidæ are proposed by Mr. Etheridge for shells occurring in this division; one, *Pseudavicula*, of which the type is *Lucina anomala*, Moore, and the other *Maccoyella*, for *Avicula Barklyi*, Moore. Mr. Etheridge considers that the Rolling Downs Formation contains an admixture of Oolitic as well as Cretaceous forms. The most prevalent fossils in it are *Inoceramus* and *Belemnites*.

The Desert Sandstone, which is considered to be of Upper Cretaceous age, is thought to have formerly covered three-fourths of the colony, but it is now restricted to narrow areas of table-lands which rest on the Rolling Downs Formation and older rocks. It appears principally to consist of sandstones and conglomerates, mostly of quartz pebbles. Some portions of these rocks may possibly be of lacustrine origin, whilst in others shells of *Ostræa* and other marine bivalves occur. A few plant remains have also been found in this formation; the most important of these are specimens of undoubted *Glossopteris*, a fern which has been by some authorities considered characteristic of Palæozoic strata, though Prof. McCoy restricted it to the Mesozoic. In Queensland, previous to its discovery in the Desert Sandstone or Upper Cretaceous, it was only known from the Permo-Carboniferous of the Bowen River Coal-field. The same genus, as is well-known, occurs in the Jurassic strata of India.

There is no distinct evidence of the occurrence of Tertiary strata in Queensland, but this period seems to have been marked by movements of elevation accompanied by great volcanic activity. The volcanic rocks have been divided into a Lower series, which was laid down after the elevation of the Desert Sandstone and before it had been denuded to any great extent; and an Upper series, which belongs to a subsequent period of eruption, of which the vents are still extant.

In all parts of the colony the remains of extinct birds, reptiles and mammals have been found in the post-Tertiary Fluviatile Drifts, mostly in breccias and indurated muds which represent the beds of old water-courses through which the present creeks have cut their channels. Very little attention appears to have been given to these fossils at present. The shells of fresh-water Molluscs associated

with these vertebrates, all appear to belong to existing species. No human bones, flint-flakes, or native weapons, have ever been found associated with extinct mammalia in Queensland.

The chapter on the Geology of British New Guinea is based mainly on the report of Mr. A. Gibb Maitland, of the Geological Survey of Queensland. From this it appears that on the north-east coast of this island there are numerous raised coral reefs, presenting all gradations of height from only a few feet above the water to an elevation of 2000 feet. Beds of sandstone and grit in the Kevori district are considered to be of post-Tertiary age, and the sandy limestones and shales with flint nodules at Port Moresby are regarded as Tertiary. An immense area, extending from Port Moresby to the German boundary, is occupied by metamorphic rocks. From the fossils obtained from different sources, Mr. Etheridge has determined that the oldest fossiliferous rocks in New Guinea, known up to the present, probably correspond homotaxially with the Upper Oolites of other countries.

In the concluding chapter petrographical notes on specimens from Queensland and adjoining countries are contributed by Mr. A. W. Clarke, F.G.S.

A very complete index, arranged under the headings of Persons, Places, Subjects, and Genera, Species and principal Synonyms, greatly facilitates the work of reference, and Mr. Etheridge also gives a list of papers relating to the Palæontology of Queensland and New Guinea. To this list a paper by Mr. A. H. Foord on Western Australian Fossils (Geol. Mag. Vol. VII. 1890) giving references to forms occurring in Queensland, might be added.

The plates illustrating the fossils, rock specimens, etc., are bound in a separate volume. The major portion were drawn and lithographed in this country by Messrs. Berjeau and Highley, and it is hardly necessary to add that they reach a high standard of excellence which could hardly be looked for in the plates executed in Queensland.

The importance of this work as a solid contribution to geology generally, and its particular value to that of Queensland, require no comment; and its authors deserve the acknowledgments of all interested in the science. We are also glad to see that the Government of Queensland recognizes the value of the work in making known the mineral resources of the colony.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 12th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Palæozoic Ostracoda from Westmoreland." By Prof. T. Rupert Jones, F.R.S., F.G.S.

In 1865 the author determined for Prof. Harkness some fossil Ostracoda which he had obtained from the Lower Silurian rocks of S.E. Cumberland and N.E. Westmoreland, and subsequently other specimens mentioned by Harkness and Nicholson in 1872. In

1891 Prof. Nicholson and Mr. Marr submitted a series of similar microzoa from the same district; and the author now endeavours to determine their specific alliances, and revises the list of those previously collected. He has to notice about eleven forms of *Primitia*, *Beyrichia*, *Ulrichia*, *Æchmina*, and *Cytherella*—several of them being closely allied as varieties, but all worthy of study as biological groups, such as have been illustrated from other regions by writers on the Ostracoda, with the view of the exact determination, if possible, of species and genera, of their local and more distant or regional distribution, and of their range in time.

2. "On some Palæozoic Ostracoda from the Girvan district in Ayrshire." By Prof. T. Rupert Jones, F.R.S., F.G.S.

This paper aims at the completion of the palæontological account of the Girvan district, as far as the Ostracoda are concerned; and follows up the researches indicated in the "Monograph of the Silurian Fossils of the Girvan District in Ayrshire," by Nicholson and Etheridge, vol. i. 1880.

In about a dozen pieces of the fossiliferous shales, submitted for examination some few years ago, the writer finds nearly thirty specimens of *Primitia*, *Beyrichia*, *Ulrichia*, *Sulcuna*, and *Cypridina*, which show interesting gradations of form, not always easy to be defined as specific or even varietal, but valuable as illustrating modifications during the life-history of individuals, thus often leading to permanent characteristics of species and genera. Like those formerly described in Nicholson and Etheridge's "Monograph," the specimens have all been collected by Mrs. Elizabeth Gray of Edinburgh.

3. "On the Dwindling and Disappearance of Limestones." By Frank Rutley, Esq., F.G.S.

The existence of chert between two sheets of eruptive rocks at Mullion Island seemed to the author to require some explanation. Cherts are usually associated with limestones, and the absence of limestones in many cases where cherts are found points to their removal by underground waters. The older the limestone, the greater the probability of its thickness having dwindled. The thicknesses of the Ordovician, Silurian, Devonian, and Carboniferous Limestones seem to be in the ratio of 1 : 15 : 15 : 100. Many limestones once existing in Archæan rocks may have disappeared, as also limestones in later rocks.

The author comments on the difficulty of distinguishing some cherty rocks from felstones.

Two Appendices are added to the paper, the first on the transference of lime from older to newer deposits, and the second on the formation of nodular limestone bands.

4. "On some Bryozoa from the Inferior Oolite of Shipton Gorge, Dorset.—Part II." By Edwin A. Walford, Esq., F.G.S.

As we pass backward in time, the characters of the two sub-orders Cheilostomata and Cyclostomata merge. The accessory organs of the genus and species described in this paper illustrate this statement. The genus is named *Pergensia*, and the following new

species are described:—*P. nidulata*, and vars. *major* and *minima*, *P. porifera*, *P. amphoralis*, *P. jugosa*, *P. bigibbosa*, and *P. galeata*. This genus is, however, placed in the sub-order Cheilostomata, thus recognised for the first time in the Jurassic Series.

II.—April 26th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Origin of the Crystalline Schists of the Malvern Hills." By Charles Callaway, D.Sc., M.A., F.G.S.

This paper was the third of a series of three. In the first of these, published in the Quarterly Journal in 1887, the author contended that many of the gneisses and schists of Malvern were formed out of igneous rocks. In the second, which appeared in the Journal in 1889, he discussed the origin of secondary minerals at shear-zones in the Malvern rocks, and arrived at the conclusion that all the mica and much of the felspar, to say nothing of quartz and other minerals, were of secondary origin. In the present paper the author first pointed out that some of the most important mineral changes described in his second communication—such, for example, as the conversion of chlorite into biotite—had since been confirmed by independent investigators. He held that, as a whole, the gneisses and schists of Malvern had been formed by the crushing and shearing of consolidated igneous rocks; but he did not deny the possibility that here and there the foliated structure might have been produced in a fused mass. In the first stage of metamorphism the diorite or granite was crushed and decomposed. This slightly compressed rock could be traced step by step into a typical gneiss or schist. The signs of pressure progressively increased, and the mineral and chemical changes became proportionately greater. Reconstruction set in. The process of metamorphism did not always follow the same lines. Felspar was sometimes crushed into seams of fragments, and these, by partial re-fusion and pressure, were converted into gneissose lenticles of quartz and felspar. Intervening chlorite was changed to biotite, or even to muscovite or sericite. Thus a typical gneiss, consisting of quartz-felspar lenticles in a felt-work of mica, was formed out of a diorite. Sometimes the felspar was reconstituted without becoming fragmental, and it was then deposited on, or it included, idiomorphic mica; or a soda-lime felspar might, by a process of corrosion, be converted into quartz, or a soda-felspar, or both.

In an early stage of metamorphism, the rock was often dirty and rotten through the abundance of chlorite and disseminated iron-oxide. The former being changed to mica, and the latter being either absorbed in the production of biotite, or reconstituted in a crystalline form, a sound clear gneiss was the result. In the completed product, the signs of crushing and shearing were often entirely wanting. Even strain-shadows were rare in it. The metamorphism, however, was demonstrated in numerous localities by tracing the gradations inch by inch, and by the subsequent study of large numbers of microscopic slides, in which the transition was still more clearly seen than in the field.

The classification of the Malvern schists originally proposed was somewhat enlarged, the injection schists being subdivided into (1) Schists of Primary Injection, in which one rock was injected into another, and (2) Schists of Secondary Injection, formed by the infiltration of secondary minerals along shear-planes.

One of the most important of the chemical changes produced in the conversion of a diorite into an acidic schist was the elimination of magnesia. This was proved by analyses. The recent researches of Mr. Alexander Johnstone had shown that even in the laboratory, and at the ordinary temperatures, carbonated waters were able to remove magnesia from certain of its combinations with silica.

2. "Supplementary Notes on the Metamorphic Rocks around the Shap Granite." By Alfred Harker, Esq., M.A., F.G.S., and J. E. Marr, Esq., M.A., F.R.S., Sec.G.S.

This paper contains some additions and corrections to the work submitted to the Society by the authors on a previous occasion (see Quart. Journ. Geol. Soc. vol. xlvii. p. 266). In the present communication special attention is paid to the alteration of a group of basic volcanic rocks by the granite.

III.—May 10th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

1.—"The Felsites and Conglomerates between Bethesda and Llanllyfni, North Wales." By Prof. J. F. Blake, M.A., F.G.S.

The author brought forward fresh evidence in support of the views he had previously expressed as to the Cambrian age of these felsites, and as to the unconformity of the conglomerates on the Purple Slates.

A new Tunnel Section at Penrhyn Quarry was described, in which felsite was followed by St. Ann's Grit with a Conglomerate-band, and there lying in the midst of the Cambrian Series. After a word or two on the conglomerate on Moel Rhiw-wen, the sections on either side of Llyn Padarn were discussed in detail, and it was shown that the distribution of the rocks on the surface of the country could only be explained by the unconformable position of the conglomerates and grits, which, moreover, lie nearly horizontal.

After a discussion of the conglomerates of Bettws-Garmon, a detailed section of the adit at Moel Tryfaen was given, in which it was shown that there was only a 3ft. 6in. band of conglomerate next the Purple Slates, followed by 1350 feet of Banded Slates and Laminated Grits with four distinct intercalated bands of felsite; and it was argued that the conglomerate on the summit, 55 yards across, could scarcely be represented by this thin band. Finally, the distribution of rocks on Mynydd-y-Celgwyn was shown to be satisfactorily explained by unconformity.

Incidentally it was mentioned that a band of rock in the felsite at Llyn Padarn, which had been considered to be a deposited slate, was in reality an intrusive igneous rock.

The conglomerates described were considered to be an overlap of the Bronllwyd Grit.

CORRESPONDENCE.

CLAIM OF PRIORITY.

SIR,—My friend Mr. G. C. Crick, of the British Museum (Nat. Hist.), has drawn my attention to the fact that Mr. S. A. Miller, of Cincinnati, has proposed (Advance Sheets, 18th Report, Geol. Surv. Indiana, p. 71) a new genus—*Streptodiscus*—for *Nautilus stygialis*, de Koninck, and its allies—to replace *Trematodiscus*, erected by Meek and Worthen (Proc. Acad. Nat. Sci. Philadelphia, 1861, p. 147), and *Trematoceras*, proposed by Hyatt in 1883, both these names being preoccupied, the first by Häckel for a genus of Radiolarians, the second by Eichwald for a *Bactrites*, and also (according to Mr. Miller) by R. P. Whitfield in 1882, for a (fossil) Cephalopod. I must be permitted, however, to point out to Mr. Miller, and to all whom it may concern, that I proposed the name *Cœlonautilus* for *Nautilus cariniferus*, Sowerby, first in a paper by Mr. G. C. Crick and myself (GEOL. MAG. Decade III. Vol. VI. p. 494; 1889), and afterwards, with a full description of the genus in the "Catalogue of the Fossil Cephalopoda in the British Museum (Natural History)," Part II. 1891, p. 105, I enumerated in this place the following species as falling within *Cœlonautilus*, viz. *Nautilus stygialis* (as type), *N. Edwardsianus*, *N. Omalianus*, and *N. pinguis*, de Koninck (not *N. pinguis*, M'Coy), together with *N. sulcatus*, *N. cariniferus*, etc. of J. de C. Sowerby.

ARTHUR H. FOORD.

DUBLIN, *April* 14, 1893.

MISCELLANEOUS.

THE MURCHISON GOLD-FIELD.—WESTERN AUSTRALIA has lately added another Gold-field to its possessions, the proclaimed area of which is 32,000 square miles. This field was discovered in 1891 and has just been reported upon[1] by Mr. Harry Page Woodward, F.G.S., the Government Geologist for the Colony. The principal auriferous belt is situated on the eastern side of the area, about 200 miles from the coast, running in a north and south direction. Taken as a whole, the field is exceedingly rich, and will probably extend for a great distance eastwards. Water is abundant and at shallow depths, for which the district is celebrated; timber is scarce. This field has a brighter outlook than any other in the Colony, having neither the distance to Kimberley nor the salt-water of Yilgarn to contend with. On the east side of the Weld Range, is the celebrated "Wilgie Myah," probably one of the largest Iron-lodes in the world, composed almost entirely of hæmatite in immense botryoidal masses. The natives quarry it to obtain the red and yellow ochre with which they love to adorn their persons. The place has probably been worked by the aborigines for hundreds of years before the white man set foot in Australia.

[1] Issued in Perth, W.A., April, 1893.

ERRATUM.—Readers of the GEOLOGICAL MAGAZINE are requested to make the following correction in legend to woodcut on p. 207 of Prof. Bonney's article in the May Number, 1893:—

For "*G* seems to *quadrate in A*," etc., read "*G* seems to *graduate into A*," etc.